# Site Investigation Report for the Johnny M Mine and Adjacent Properties

**DRAFT**

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## Acronyms and Abbreviations

| | |
|---|---|
| AOC | Settlement Agreement and Administrative Order on Consent for Removal Action |
| ASTM | ASTM International |
| bgs | below ground surface |
| bkg | background |
| BRA | background reference area |
| c $min^{-1}$ | counts per minute |
| CL | clay |
| cm | centimeter |
| CRDL | contract required detection limit |
| EE/CA | Engineering Evaluation/Cost Analysis |
| EDD | electronic data deliverable |
| EPA | U.S. Environmental Protection Agency |
| ft | feet/foot |
| gamma | gamma radiation |
| GIS | geographic information system |
| GPS | global postioning system |
| HPIC | high pressure ion chamber |
| ICP-MS | Inductively Coupled Plasma-Mass Spectroscopy |
| in. | inch |
| Itasca | Itasca Denver, Inc. |
| MDC | minimum detectable concentration |
| NM | New Mexico |
| NMED | New Mexico Environment Department |
| NMEID | New Mexico Environment Improvement Division |
| NORM | naturally occurring radioactive materials |
| m | meter |
| m $s^{-1}$ | meters per second |
| mg $kg^{-1}$ | milligrams per kilogram |
| min. | minute |
| OH | organic clay, organic silt |
| pCi $g^{-1}$ | picocuries per gram |
| pcf | pounds per cubic foot |

## Acronyms and Abbreviations (concluded)

| | |
|---|---|
| PRL | practical reporting limit |
| QA/QC | quality assurance/quality control |
| RER | replicate error ratio |
| RPD | relative percent difference |
| S | sand |
| SAP | Site Assessment Plan |
| SC | clayey sand |
| SIR | Site Investigation Report |
| SM | silty sand |
| SP | poorly graded sand |
| SVOC | semi-volatile organic compound |
| TCLP | toxicity characteristic leaching procedure |
| TPU | total propagated uncertainty |
| UNM | University of New Mexico |
| $\mu R\ h^{-1}$ | microRoentgens per hour |
| USCS | Unified Soil Classification System |
| USGS | U.S. Geological Survey |
| VOC | volatile organic compound |

## Executive Summary

This Site Investigation Report (SIR) for the Johnny M Mine and adjacent properties (project area), near San Mateo, New Mexico documents the implementation of the Site Assessment Plan (SAP), which was conducted in accordance with the Settlement Agreement and Administrative Order on Consent for Removal Action (AOC), dated August 16, 2012, between Hecla Limited and New Mexico Land, LLC; and the U.S. Environmental Protection Agency.

The purpose of this SIR is to summarize the actions taken and data obtained pursuant to the SAP in the AOC, present the analytical results of all sampling and analyses performed, identify background radiological conditions, and estimate the approximate volumes of mine-related material to be managed.

This report provides 1) information to characterize the nature and extent of radiological and chemical constituents of mine-related material in the project area; 2) an understanding of the means and paths of transport of mine-related material; 3) the data obtained in a representative background reference area (BRA); 4) volume estimates of mine-related materials; 5) information to determine potential repository locations in the project area; and 6) information regarding the location and suitability of liner, erosion control, and cover materials, if needed. This information will be used in an Engineering Evaluation/Cost Analysis (EE/CA).

Radiological and chemical data were collected by Environmental Restoration Group, Inc. Geotechnical and geomorphological data were collected by Alan Kuhn Associates, LLC.

Field activities included geomorphological field and Global Positioning System (GPS)-based radiological surveys; gamma radiation (gamma) measurements at fixed points; and soil sampling for geotechnical parameters, radionuclides and chemicals: specifically, select indicator metals. Soil sampling for radionuclides --and select indicator metals by extension-- was guided by down-hole gamma measurements.

The areal extent of mine-related materials was estimated using the results of gamma surveys and visual observations. Surface elevations were estimated by merging data from historical and current topographic surveys. The depths of mine-related materials were estimated using results of down-hole logging, soil sampling, and geotechnical observations.

The findings of the investigation are:

- The horizontal and vertical extents of potential mine-related materials were delineated sufficiently to support remedy selection and design.

- A representative BRA was established in Area B. The BRA is isolated from mine-related materials in the project area and its soil types are representative of the majority of low-lying portions of Area C.

- The estimated volume of mine-related materials using the 5 picocuries per gram (pCi $g^{-1}$) radium-226 plus background standard applied at the San Mateo Mine is 265,000 cubic meters ($m^3$).The estimated volume is 450,000 $m^3$, delineating to the project area background concentration of radium-226 (0.9 pCi $g^{-1}$).

- Indicator metals are sufficiently co-located with radium-226 such that radium-226 field results can be used to guide the remediation, if any, of mine-related materials.

- Any transport of mine-related material is primarily limited to runoff from Area A and sedimentation in arroyos.

- Mine-related materials in the project area are not impacting surface water or groundwater quality on or downgradient from the project area. Groundwater at the uninhabited residence on Area C is upgradient of the mine.

- Onsite (Areas A, B, and C) sources of soil cover material are adequate for in-place stabilization.

- Area A and the north-central part of Area C have geotechnical and geomorphological attributes that are suitable for location of a repository for mine-related materials.

# Section 1.0 - Introduction

## 1.1 Background

This site investigation resulted from previous investigations conducted by the U.S. Environmental Protection Agency (EPA) (EPA, 2010; EPA, 2011; EPA, 2012a). These included an aerial flyover gamma radiation (gamma) survey, global positioning system (GPS)-based radiological surveys; and indoor radon, groundwater and soil sampling and analysis. These investigations showed that surface and near surface soils at the Johnny M Mine and adjacent properties contained mine-related material with naturally occurring radioactive materials (NORM).

This site investigation was guided by the Settlement Agreement and Administrative Order on Consent for Removal Action (AOC), dated August 16, 2012, between Hecla Limited and New Mexico Land, LLC; and the EPA, which provides a framework to conduct the investigation and plan for an effective remedy. The investigation followed the methods and quality assurance procedures presented in "Site Assessment Plan for the Johnny M Mine and Adjacent Property" (SAP) as included in Appendix B of the AOC.

## 1.2 Purpose

The purpose of this Site Investigation Report (SIR) is to summarize the actions taken and data obtained pursuant to the SAP in the AOC, present the analytical results of all sampling and analyses performed, identify background radiological conditions, and estimate the approximate volumes of mine-related material to be managed.

## 1.3 Scope

This SIR provides 1) information to characterize the nature and extent of radiological and chemical constituents of mine-related material in the project area; 2) an understanding of the means and paths of transport of mine-related material; 3) the data obtained in a representative background reference area (BRA); 4) volume estimates of mine-related materials; 5) information to determine potential repository locations in the project area; and 6) information regarding the location and suitability of liner, erosion control, and cover materials, if needed. This information will be used in an Engineering Evaluation/Cost Analysis (EE/CA).

## 1.4 Site Background

The background of the project area includes descriptions of the location, project area, setting, man-made features, operational history, and previous investigations.

### 1.4.1 Location

The project area is located on private land within the Ambrosia Lake mining district in McKinley County, New Mexico (NM), just north of New Mexico Highway 605 and 4.4 miles west of the village of San Mateo (see Figure 1-1).

### 1.4.2 Project Area

The project area includes the historic Johnny M Mine (hereinafter Area A) and adjacent properties of interest, specifically the properties west of Area A within the western half of Section 18 (hereinafter Area C); and within both the eastern half of Section 18 and southern half of Section 7 (hereinafter Area B); and any drainage pathways to the west of Area C. These three areas lie within Township 13 North, Range 8 West.

Figure 1-2 shows the project area and BRA referred to in this SIR.

### 1.4.3 Setting

The geography of the project area is representative of northwestern New Mexico and, specifically, the San Juan Basin. San Juan Basin topography is characterized by the combination of two land forms: mesas which dip gently to the north and broad valleys with intermittent streams. Arroyos have incised the mesas by headward erosion, forming steep-sided canyons.

Area A is relatively flat and bordered on three sides by mesas extending to approximately one hundred feet above the mine. The project area broadens south, east, and west of the mine. An east-west trending drainage (hereinafter the primary arroyo) crosses the southern edge of Area A and extends to the western edge of Area C. A small mesa outcrops in the west-center of Area C. The mesa that curves around three sides of Area A also crosses the middle of Area B, occupying approximately 40 percent of the latter. The lower portions of Area B lie in its northwest and southeast corners, and in the east.

Livestock grazing is the predominant land use within one kilometer of the project area. The vicinity of the project area is sparsely populated: the small town of San Mateo is approximately 4.4 miles to the southeast.

The project area is proximal to the San Mateo Mine, which is expected to have similar environmental conditions and mine-related materials.

The climate of the project area and surroundings is classified as semi-arid continental. A detailed description of the climate typical of the location is provided in the SAP.

### 1.4.4 Man-Made Features

Man-man features in Area A include a rusted metal half- cylindrical overhang, at the back of which are a partially-collapsed elevated wooden platform and locked vault door. There are several concrete pads; two of which contain circular concrete shaft plugs. An open pipe protrudes from one of these plugs. In addition, there are several subsurface cylindrical metal vaults and vertical pipes. The largest of the subsurface vaults contains a tank and pump. Some of the former contain pipes, and/or are only partially covered with metal plates. A fenced area with five concrete pads remains. There are power lines and poles in the project area. There are pieces of thin wire exposed in the soil and small amounts of iron and wood debris scattered around Area A. Finally, the drainages along the edge of the Area A contain concrete debris, pipes, and exposed wires. There are two former sedimentation ponds in Area A, currently covered, within historically reclaimed areas. These are discussed in Section 1.4.5.

There are largely no man-made features on Area B, other than fences, electricity poles, and roads.

Area C contains an uninhabited residence and corral: the area around the latter appears to have been graded. Debris is present in the north-south trending drainage at the north end of the area. Segments and pieces of transite pipe, along with steel pipe, occur along the former path of a discharge pipeline. There are pop-ups for telephone wires along the road leading to the structures from Highway 605. Finally, there are two historic monitoring wells in the southern portion of Area C, near Highway 605.

### 1.4.5 Operational History

Development of the Johnny M Mine began in 1972. The first ore was produced in 1976. Ore production ended in 1982. All ore was shipped offsite for the milling and recovery of uranium. Uranium mill tailings were brought onto the Johnny M Mine for use as underground structural support material (backfill as part of the mining operation), an activity requiring a Radioactive Materials License (License), which was obtained from the State of New Mexico. New Mexico relinquished oversight of the uranium recovery licensing program, and therefore the License, to the Nuclear Regulatory Commission, prior to termination of the License.

A description of mine water treatment bears importance to findings in this SIR, and the previous investigations described in Section 1.4.6. Mine water was treated using Nalco 8114™ coagulant and a barium chloride solution, under a New Mexico Environment Improvement Division (NMEID)-approved discharge plan (NMEID, 1978). Two sedimentation ponds were in the treatment loop. Each of the ponds was approximately 100 by 400 by 15 feet (ft) deep and reportedly constructed subgrade (NMED, 2010). The treated water was conveyed from the ponds via the discharge pipeline.

### 1.4.6 Previous Investigations/Cleanups

The AOC focuses on mine-related materials currently on the project area. Investigations related to these materials began with a nominal aerial radiological assessment, followed by GPS-based gamma surveys; and soil sampling and analysis. All investigation activities conducted prior to those described in this SIR were conducted by the EPA and/or NMED.

The aerial radiological assessment was conducted over the nominal Ambrosia Lake and Laguna Uranium Districts in October 2009 (EPA, 2010). Additional investigations within the project area, conducted as a response to the findings of the aerial survey and land use, occurred from 2010 through 2012; and consisted of GPS-based gamma surveys; indoor and outdoor high pressure ion chamber (HPIC), static (integrated) and down-hole gamma measurements; and soil and groundwater sampling.

Relevant results of the previous GPS-based gamma surveys and soil sample sampling and analysis are discussed in Sections 4.1.3.2 and 4.2.2.1, respectively.

# Section 2.0 - Site Investigation Activities

## 2.1 Scope of Activities

Consistent with the SAP, the scope of the investigation includes GPS-based gamma surveys, gamma measurements at fixed points, soil sampling for radionuclides (naturally occurring gamma-emitters, natural uranium, and isotopes of thorium) and indicator metals (arsenic, barium, lead, molybdenum, selenium, and vanadium), down-hole gamma measurements; geomorphological and geotechnical observations and/or measurements; and a temporary stabilization measure.

Table 2-1 --adopted from the SAP-- provides a summary of the activities, their relevance to the scope, and parameters evaluated. The only activity not identified in the SAP is the analysis of a sample of pond sediment for additional characteristics. The sample was collected because it had a hydrocarbon odor. This SIR describes the collection and results for the sample.

Finally, this SIR includes an evaluation of groundwater and surface water conditions in the project area to support the preparation of the EE/CA. This information is included in a report prepared by Itasca Denver, Inc. (Itasca), attached as Appendix I.

# Section 3.0 – Methods

This section provides a summary of the methods used to conduct the site investigation.

## 3.1 Field Surveys

The methods used for ground control and location; and geomorphological and radiological surveys are described in the following sections.

### 3.1.1 Ground Control and Location Survey

Field investigations, including sampling locations and visual observations, were referenced to existing U.S. Geological Survey (USGS) topography and Geographic Information System (GIS) data accessed at http://rgis.unm.edu/browsedata (University of New Mexico [UNM], 2012). Local ground control was established using currently visible fence lines, property corners, and mine features. Locations and elevations of sample points were referenced to these features and determined using GPS survey methods.

The primary survey instruments were two Topcon GR-3 GPS units mounted on a tripod base, rods, and a Topcon datalogger. The GR-3 instruments were calibrated by the equipment vendor, with horizontal and vertical accuracies of 3 and 5 millimeters, respectively. One GR-3 functioned as a base unit and the other as a rover unit. The base station was set up on a tripod over a local base point and the rover unit was mounted on a survey rod and used to collect the data points. The two units received position and elevation data, using GPS technology. The rover GPS data were corrected automatically by comparing its readings with the base unit. The two units communicated via Bluetooth wireless technology.

Known nearby recent survey control points or bench marks were unavailable at the site, so a local base point (top of the well casing located near the uninhabited residence in Area C) was established to obtain relative elevation and position data. The assumed elevation for this point was determined by interpolating from the most recent USGS San Mateo quadrangle topographical data. Subsequently, surveyed point elevations were referenced back to the local base point. Each point was entered into the Topcon data logger connected to the rover unit, then downloaded to a personal computer and processed into GIS and AutoCAD formats using Topcon software.

Additional topographic data were collected to assist in preparing a more detailed topographic map. These points were selected from topographic features such as the top of a slope or the bottom of an arroyo channel. These data then were downloaded into an AutoCAD file and compared against the USGS topographic map for the site.

The coordinates and elevations of each sample location, key site feature, and the visible boundaries of mine waste were recorded using these GPS methods. Elevations of the sample points (at ground surface) were subsequently determined using the Topcon GR-3 units.

### 3.1.2 Geomorphological Survey

The geomorphological survey consisted of an initial aerial photo and satellite imagery study, followed by an onsite study of visual observations and photography, as described in Section 2.4 of the SAP.

Historical aerial photos dated 1973, 1974, 1977, 1983, and 2005 were examined for changes in landforms, especially arroyos, that indicated areas of erosion, sedimentation, or mass wasting (rock falls, landslides) in the project area. These were also compared to the most recent Google Earth satellite images of 2012. The historical aerial photos also were used to estimate the location and extents of the sedimentation ponds. Figure 3-1 is the 1977 aerial photo; and identifies the two sedimentation ponds (Pond 1 and Pond 2), primary arroyo, and other historical features of the mine, prior to closure. The current uninhabited residence and former corral (stables) are shown in the figure for positional reference.

Visual observations were made during walking surveys conducted on September 8 and 19; and October 16, 2012. The surveys focused on Areas A, B, and the northern part of Area C to 1) confirm and/or correct geomorphological information obtained from the aerial photographs and satellite image studies; and 2) take photographs and note terrain features not visible on, or readily studied on, aerial photos. A log of photographs and map index were created to document the visual observations of aggrading and degrading terrain features, including headcutting and deposition along arroyos; vegetation patterns and stability in arroyo channels, mesa slope retreat, and talus development. Appendix A presents the photo log, map, and photos. Geomorphological features were noted on the site base map.

### 3.1.3 Radiological

Consistent with Sections 2.1 and 2.2 of the SAP, the components of the radiological field surveys were 1) GPS-based gamma surveys conducted in Areas A, B (includes the BRA), C and the drainage west of Area C; 2) static gamma measurements taken in Area A to mitigate the potential effects of scattered gamma (gamma shine) in evaluating the areal extent of NORM associated with mine-related material; and 3) co-located HPIC and gamma count rate measurements.

To assist the reader, there are notable differences between scanning and static (integrated) gamma measurements. Scanning measurements are those recorded during the GPS-based gamma survey, with the ratemeter/scaler in ratemeter mode. Count rate measurements are recorded every second in this method and stored individually, each with its own geoposition. Static measurements, on the other hand, are recorded, in the case of this investigation, at one location for one minute (min.), with the ratemeter/scaler in scaler (integrating) mode. In this mode, the detector integrates the number of interactions (counts) within the 1 min. counting period. Both types of measurements are reported as counts per minute ($c\ min^{-1}$).

#### 3.1.3.1 Gamma Surveys

This section describes the methods used to conduct the GPS-based gamma and static measurement surveys.

***GPS-based***

Gamma surveys were conducted using Ludlum Model 44-10, 2-inch (in). by 2-in. sodium iodide high energy gamma-radiation detectors, each coupled to a Ludlum Model 2221 ratemeter/scaler that was, in turn, coupled to a Trimble ProXRS GPS unit with a Juniper TK6000 datalogger. All areas were surveyed at an approximate speed of 0.6 $m\ s^{-1}$ (meters per second) with the detectors held at approximately 0.5 m above the ground surface. Field personnel performed the survey on September 10-12, 14, and 20, 2012 using all-terrain vehicles or walked, carrying the instrumentation in backpacks. Gamma count rates were recorded every second on approximately 50 m, north-south transects, with individual count rates logged with associated New Mexico State Plane location coordinates. The coordinate system was NAD1983, New Mexico West.

Gamma count rates obtained in the survey were downloaded into ArcGIS (ArcMap version 10). The data were grouped according to the project area and BRA; and exported as shape and database files for statistical analysis.

The detectors (Serial Numbers 254757/PR199131 and 254772/PR118372) were matched to yield similar responses during calibration to a National Institute of Standards and Technology-traceable cesium-137 check source, and function-checked daily, prior to and after the work day. Appendix B presents the instrument calibration forms. This appendix includes all of the forms for the instruments used for the GPS-based radiological surveys; and static, HPIC-gamma measurements, and down-hole measurements described below.

***Static measurements***

Static measurements were used in Area A to assess the influence of gamma shine, originating from mine-related material and scattering off the canyon walls, on the measurements obtained in the GPS-based gamma survey.

The static measurement survey was performed in Area A on October 8, 2012, in accordance with the method described in Section 2.1.1 of the SAP. A 20 by 20-m square grid was established across Area A as shown in Figure 3-2. Two, 1-min. static measurements --one with an unshielded detector (unshielded measurement) and one with it placed within a lead collimator (shielded measurement)-- were made at each grid node. The shielded measurements were made with the collimator pointed down and placed on the ground, to minimize the contribution of gamma from areas other than at the point directly below the detector. The detector lies approximately 15 centimeters (cm) above the ground surface in this configuration. The unshielded measurements were taken at approximately 0.5 m above the ground surface. One detector was used to make both measurements at a given location.

***HPIC measurements and correlation***

Field personnel made co-located one-minute static count rate and HPIC exposure rate measurements at ten locations representing the range of gamma count rates obtained in the GPS-based gamma survey. The gamma and HPIC measurements were made on September 15, 2012 at 0.5 m and 1 m above the ground surface, respectively. The latter were recorded at six-second intervals for about 5 min. and an exposure rate was determined from the average of these measurements. The sodium iodide detector was one of the two used in the GPS-based survey and the HPIC was a Reuter Stokes Model RSS-131 (Serial Number 07J00KM1).

Figure 3-3 shows the locations of the co-located measurements.

A linear regression model of the co-located measurements --predicting exposure rates from gamma count rates--was developed using MS Excel. A project area-wide map, depicting the exposure rates predicted from the gamma count rates obtained in the GPS-based survey, was produced using ArcMap GIS. In addition, the set of predicted exposure rates was evaluated statistically and spatially.

Because the predicted values are multiplicative and additive factors of gamma count rates, figures depicting project area-wide scanning gamma count rates and predicted exposure rates will appear similar. Of these, we have chosen to display in Section 4.1.3.2 only the predicted exposure rates, because they can be compared directly to future gamma survey data with proper correlation to exposure rate.

The HPIC was in current calibration and function checked before and after use. Calibration forms for the HPIC are provided in Appendix B.

### 3.2 Soil Sampling

This section describes the methods used to sample soils for geotechnical parameters, radionuclides, and indicator metals. It includes identification of the laboratory analytical methods. Soil sampling was conducted in general accordance with Section 2.3 of the SAP.

#### 3.2.1 Sampling Locations

Figure 3-4 depicts all of the radionuclide/indicator metals soil sample locations of the investigation.

Figure 3-5 shows the geotechnical and radionuclide/indicator metals soil sample locations in Area A. Several of the locations were sampled for both geotechnical parameters and radionuclides/indicator metals. Note that all the geotechnical samples were collected in Area A, with the exception of three samples of sandstone, collected in Area C (locations not shown).

Consistent with Section 3.5.3 of the SAP, the sample locations are classified as follows:

- BRA (15 locations for radionuclides/indicator metals: BRA series)
- Area A (12 locations for geotechnical parameters and radionuclides/indicator metals: AA series)
- Area B (5 locations for radionuclides/indicator metals [AB series])
- Area C (23 locations for radionuclides/indicator metals [AC series])

The identifiers for geotechnical samples are not addressed in the SAP. The sample locations are classified as follows:

- Area A (6 locations each, for geotechnical [GEO-A series] and bulk samples [GEO-B series])
- Area C (3 locations for geotechnical [GEO-R series])

#### 3.2.2 Geotechnical

The primary soil sampling tool used for geotechnical sample collection was a Geoprobe 6620DT direct push rig with tube samplers. A licensed professional geotechnical engineer logged all but two of the borings advanced in Area A, classifying the soils in accordance with the Unified Soil Classification System (USCS). The cores were labeled with the boring number, sample depth interval, and vertical orientation.

In addition, bulk samples were collected by hand for classification and compaction testing of potential cover soil and subsequent durability testing of rock sources of rip-rap, if needed. The bulk samples were collected from surficial and shallow soils that, from visual examination, appeared to be potentially suitable borrow material for use as cover or common fill, if needed. The geotechnical engineer also selected two grab samples of sandstone from an outcrop near the uninhabited residence, for preliminary evaluation as riprap for the onsite disposal or in-place stabilization alternatives to be considered in the EE/CA process.

The project geotechnical consultant and geotechnical engineer reviewed the boring logs and soil samples, from which they selected 21 soil samples for laboratory testing. The samples represented the range of native soils and mine-related materials in Areas A and B.

The soil samples were tested by Earthworks Engineering Group in Albuquerque, New Mexico for the following properties:

- Grain size analysis, using "ASTM International (ASTM) D422-63 Standard Test Method for Particle-Size Analysis of Soils" and "ASTM D2217-85 Standard Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants."

- Plasticity, using "ASTM D4318-10 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils."

- Soil moisture, using "ASTM D2216-10 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass."

- Compacted density using "ASTM D698-12 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort."

The laboratory results were used to confirm or correct field classification of soils in accordance with "ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)." Table 3-1 lists the geotechnical methods used in this investigation.

The sandstone samples have not been tested and are being retained for future durability testing as riprap material for the alternatives of onsite disposal or in-place stabilization in the EE/CA process, if needed.

### 3.2.3 Radionuclides and Indicator Metals

Soil samples were collected in Areas A, B (including BRA), and C on October 8-11, 15, 16, and 22, 2012.

The focus of the soil sampling in Area A was the mine waste rock pile and two historic mine water sedimentation ponds, where samples were collected primarily using direct push methods. One of the borings in Area A was advanced using a hand auger. Hand augering was the predominant method used in Areas B and C, the former including the BRA. Two of the borings in Area C were advanced by way of direct push methods.

The Geoprobe 6620DT direct push rig employed 2.25-in. or 3.25-in. diameter tube corers, in which samples were collected in 1- or 2-in. diameter acetate sleeves, respectively. The samples were capped and sealed after being logged by the geotechnical engineer. As stated in Section 3.2.2, the cores were labeled with the boring number, sample depth interval, and vertical orientation. The cores were stored and secured in the barn in Area C until the down-hole logging results were evaluated, after which samples were collected from the sleeves. Unused portions of the cores are currently stored and secured in the barn.

Hand augering was accomplished using a 3.25-in. diameter, stainless steel auger. The contents of the bucket were transferred--each time it was full--to a labeled, 1-gallon Ziploc bag. Hand augering proceeded iteratively, until the bottom of mine-related material, if any, became apparent from down-hole logging measurements. The hand auger was decontaminated with de-ionized water after each sample was collected.

Sample selection was driven by the down-hole logging results, the method for which is described in Section 3.4 of this SIR and 2.3 of the SAP. Soil samples were collected from each of the locations, at the following depth intervals: 0 to 15 cm, 15 cm below ground surface (bgs) to the bottom of the radiological indication of mine-related material (as estimated from down-hole logging), and an additional 15 cm or more below this depth. In cases where the first depth interval indicated that the depth of any mining-related material had been fully penetrated, the second depth interval was not collected.

The samples were analyzed by ALS Laboratory Group, a National Environmental Laboratory Accreditation Program-certified laboratory in Fort Collins, Colorado for naturally occurring long-lived radionuclides (thorium-228, thorium-230, thorium-232, natural uranium; and gamma emitters [potassium-40 and radium-226, the latter via bismuth-214 as surrogate]) and indicator metals.

Natural uranium refers to uranium with the same isotopic ratio typically found in nature. It contains 0.7 percent uranium-235, 99.3 percent uranium-238, and a trace of uranium-234 by weight. The composition of natural uranium’s radioactivity is approximately 2.2 percent uranium-235, 48.6 percent uranium-238, and 49.2 percent uranium-234.

Table 3-1 lists the radiological and chemical methods used in this investigation.

### 3.2.4 Additional Characteristics for Pond Sediment Sample

A sample of the pond sediments was collected from Boring AA-08 and analyzed for reactive cyanide, ignitability, pH, reactive sulfide, and toxicity characteristic leaching procedure (TCLP) semi-volatile and volatile organic compounds (SVOCs and VOCs). The justification for the collection of this sample is presented in Section 4.2.1. ALS Laboratory Group analyzed the sample using EPA SW 846 Methods 7.3.1 (reactive cyanide), 1010 (ignitability), 9045 (pH), 7.3.2 (reactive sulfide), 8270 (TCLP SVOCs), and 8260 (TCLP VOCs), respectively.

## 3.3 Correlation between Radium-226 and Gamma Count Rates

Prior to soil sampling, 1-min. static gamma measurements were recorded at about 0.5 m above the ground surface in Area A (1 location), Area B (15 BRA and five additional locations), and Area C (21 locations). These were made to correlate radium-226 concentrations in surface soil (0 to 15 cm) to the 1-min. static gamma measurements, using linear regression analysis. The regression was used to predict radium-226 concentrations corresponding to the gamma count rates observed in the project area-wide survey.

### 3.4 Down-hole Measurements

Down-hole gamma measurements were made using a 1-in. by 1-in. (Ludlum Model 44-2 Serial Number PR248172) or 2-in. by 2-in. (Ludlum Model 44-10 Serial Number PR144055) sodium iodide detector, each coupled to a respective Ludlum Model 2221 (Serial Numbers 282982 and 117357, respectively). The cable lengths were 40 ft (for the 1-in. by 1-in. detector) and 10 ft (for the 2-in. by 2-in. detector). Two different detectors and cable lengths were used in anticipation of the varying diameters and depths of the borings. The cable for each detector was marked at regular intervals: 15 cm for the 2-in. by 2-in. and 30 cm for the 1-in. by 1-in. detector, respectively. The latter was used primarily for the direct push borings.

Measurements were recorded with the meter in ratemeter mode, after the count rates stabilized after about five seconds. Down-hole measurements were first recorded in the BRA, so as to determine baseline values to which measurements in other areas could be compared. Cutoff values (in c $min^{-1}$) were determined for each detector and assigned as the mean plus 2 standard deviations of the measurements made at a depth interval of 15 to 30 cm in the 15 borings in the BRA. Each of the cutoff values represents the 95 percent confidence limit for the two detectors. Thus, the vertical extent of mine-related materials in other areas, if any, could be delineated by comparing the down-hole measurements to their respective cutoff value.

All borings were backfilled with either adjacent, native soil (for borings advanced via hand augering) or bentonite (for borings advanced via direct push drilling).

### 3.5 Volume Estimates

Volumes of mine-related material were estimated by two methods, both using AutoCAD Civil 3D® software.

#### 3.5.1 Area and Volume Estimates, Excluding Sedimentation Ponds and Mine Waste Pile

The area and volume of soil apparently impacted by mine-related material in Areas A, B, and C; excluding the sediment ponds and mine waste pile, was estimated as follows:

- Shapes of areas exhibiting gamma count rates exceeding the mean plus two standard deviations value observed in the BRA in the GPS-based survey were defined using ArcGIS. This value is an estimate of the upper limit of the 95$^{th}$ percent confidence interval of the gamma count rates in the BRA. Thus, the areal extent was defined by a gamma count rate that is representative of those in the BRA. A shapefile of these areas was imported into AutoCAD and overlaid on a topographical map of the project area.

- Twenty-one shapes were made (two of which were subdivided) from these areas, based on topography, gamma count rate observations from the GPS-based survey, the placement of and observations in borings, and relative stratigraphic complexity.

- Depths in these shapes were estimated by way of interpretation of the down-hole gamma logs and radium-226 results in soil samples, if available. The cutoff values were determined from observations in the BRA. See Sections 3.4 and 4.1.3.4 for discussions of the cutoff values.

- Surface areas of each of the shapes were calculated using the AutoCAD "area" command. Each area then was multiplied by its average estimated depth.

- Each of the individual areas and volumes were added, the totals of which are the estimated area and volume of soil.

- A second set of areas exhibiting gamma count rates exceeding the equivalent of a presumed cleanup criterion (5.9 picocuries per gram [pCi $g^{-1}$]) of the mean background concentration (0.9 pCi $g^{-1}$) in surface soil of radium-226 plus 5 pCi $g^{-1}$, was defined using ArcGIS. This presumed cleanup criterion is consistent with the one established for the San Mateo Mine, located approximately 1 mile south of the project area (SAIC, 2010). A set of 21 shapes (four of which were subdivided) were made from these areas. The volumes of soil were largely determined as described in the third through fifth bullets above. However, the vertical extent was estimated from both radium-226 concentrations and down-hole measurements.

### 3.5.2 Area and Volume Estimates of Sedimentation Ponds and Mine Waste Pile

The method used to estimate areas and volumes in the sedimentation ponds and mine waste pile in Area A accounted for the more complex topography and variable depths to background levels of radioactivity in soils therein.

- Two surfaces were created in AutoCAD: 1) the existing surface topography and 2) the below-grade depths at which down-hole background gamma levels and/or the base of waste rock (in the case of the GEOA borings) were observed. The lateral limits were refined after evaluating both gamma shine in Area A (surface only) and visually-identified limits of the waste rock (subsurface and surface exposures).

- The volume estimates were obtained by plotting both surfaces in AutoCAD, comparing them therein using the volume "analyze" menu. This procedure calculates the volume between two AutoCAD surfaces using a nominal composite method, which triangulates a new surface based on points from both surfaces. This method uses the points from both surfaces, as well as any location where the edges of the triangles between the two surfaces intersect, to create prismoidal segments from composite Triangular Irregular Network (TIN) lines. The new composite surface elevations are calculated based on the difference between the elevations of the two surfaces, as depicted in Figure 3-6.

### 3.6 Temporary Stabilization Measure

A silt fence was installed in the primary arroyo on October 17, 2012, to mitigate offsite transport of sediment. The fence was installed in Area C, in what appears to be an aggrading area of the arroyo. This location is preferred to the more active, degrading sections of the arroyo, so as to maintain the integrity of the silt fence as long as possible.

Figure 3-7 is a photo of the silt fence.

## 3.7 Deviations from the SAP

Listed below are minor deviations from the SAP, none of which affect the data quality or findings of the SIR.

- Down-hole logging was performed in Area A, in lieu of ex situ measurements taken on cores. Down-hole logging provides a more accurate picture of in situ conditions, given that the detector measures gamma emissions primarily from adjacent soil, the mass of which is larger and results in a relatively higher instrument response than would be observed on cores.

- The configuration of the collimator on contact renders the detector at 15 cm above ground surface, not in contact with ground as prescribed in the SAP. This deviation is inconsequential, given that the measurements were taken in a consistent geometry.

- Table 1 of the SAP states that "Gamma count rate data will be collected at approximately 15 cm intervals at each sampling location." The cable for each detector was marked at regular intervals: 15 cm for the 2-in. by 2-in. and 30 cm for the 1-in. by 1-in. detector, respectively. The latter was used primarily for the deeper borings of Area A and marked at 30 cm. This deviation is inconsequential, given that the vertical extent of mine-related material was readily observed and gamma measurements provided a reasonable assessment of the soil profile, in all applicable cases.

- The bottom plus 15 cm sampling interval was extended from the bottom to greater depths for borings advanced using the Geoprobe, to accommodate the need for additional sample mass for the analytical laboratory. This field change was approved verbally on October 16, 2012, by Jon Rinehart of EPA (ERG, 2012).

- Two of the three soil samples collected from Boring AC-16 were switched. The deviation is inconsequential, given that the down-hole gamma measurements in the boring provide a reasonable estimate of vertical extent of mine-related materials. In addition, the error was corrected in Sections 4.2.2.1 and 4.2.2.2 by using a cross reference.

- The bags containing soil samples collected from each interval in Borings AC-21 and AC-22 were mislabeled as AC-22 and AC-21 (with the appropriate depth intervals), respectively. Given that soil sampling was guided by the down-hole measurements, only two of the three samples collected to 60 cm bgs from Boring AC-21 were submitted, when all three samples were required. Further, all three of the samples collected to 45 cm bgs in Boring AC-22 were submitted to the laboratory. Yet, only two were required, because down-hole logging indicated that the depth was 30 cm. The deviation is inconsequential, given that the down-hole gamma measurements in each of the borings provide a reasonable estimate of the vertical extent of mine-related materials. In addition, the error was corrected in Sections 4.2.2.1 and 4.2.2.2 by using a cross reference.

# Section 4.0 – Results

This section describes the results of the site investigation.

## 4.1 Field Surveys

The results of the field surveys are divided into ground control and locations, geomorphological and radiological.

### 4.1.1 Ground Control and Locations

The site survey for establishing ground control and determining locations of borings and other sampling points was performed during the week of October 15, 2012. Horizontal coordinates were determined using GPS and elevations were determined relative to local site features using the Topcon GR-3 equipment for lack of recent, local survey control monuments. Therefore, although horizontal coordinates are accurate to less than 1 m, absolute elevation accuracies cannot be ascertained from the survey. The relative elevations are accurate to within 0.5 cm.

Figure 4-1 shows the salient features and survey points.

### 4.1.2 Geomorphological

The geomorphology of the project area is typical of the mesa-and-valley terrain of the Colorado Plateau. Mesas capped by Gallup Sandstone are separated by pediments with shallow alluvial, colluival, and eolian soils. Mesa slopes are retreating gradually, over geological time, as the Gallup Sandstone caprock is undermined by erosion of the Mancos Shale below it, forming talus slopes and colluvial fans that cover the bases of the mesas. Mancos Shale underlies the project area, either outcropping or covered by colluvial/alluvial soils derived from the mesa slopes. Most of the colluvial fans are geomorphologically active with deeply incised arroyos that are actively headcutting (degrading).

Arroyos in the project area display the following characteristics:

- An upstream reach of channel erosion and headcutting into the talus and colluvial slopes. Channels are bare of deep-rooted vegetation; and side slopes are oversteepened and undercut. Erosion occurs during all runoff events.

- A midstream reach (10s to 100s of ft) over which the arroyo channel loses definition; and the sides of channels diverge and become shorter and flatter. Channel vegetation in this section is large enough to deflect most of the flow, and lower plant stems are covered by sediment. Erosion and deposition in this section is in a general equilibrium, depending on the amount of flow in each runoff event.

- A downstream reach of deposition with low, rounded channel side slopes. Channel vegetation in this reach is relatively substantial in size and density, similar to the surrounding ground. Deposition occurs therein, during most runoff events.

Arroyos disappear once they reach the valley floors (pediments) due to active aggradation, or deposition of sediment eroded from the colluvial fans, with the exception of the major watershed channels. No major watershed channels cross the project area. In general, each arroyo system originating on the mesas north and east of Areas A and C has an upstream reach and a downstream reach separated by a short midstream reach. Figure 4-2 shows the actively eroding (upstream), transitional (midstream), and actively aggrading (downstream) sections of the arroyos.

The primary arroyo (shown on Figure 3-1) running east to west across Area B, south of area A, has an actively eroding (degrading) reach east of Area B, in the headwater canyons. From east of the former pipeline crossing to 100-200 ft west of the property fence in Area C, the midstream reach of the primary arroyo appears to be in equilibrium with the current hydrologic regime. The secondary arroyos, tributaries of the primary arroyo that extend north toward Area A, display upstream characteristics with headcutting into mine-related material and underlying native soils. To the west, the downstream reach of the primary arroyo has an aggrading channel through most of Area C (see Figure 4-2). The part of Area C around the former home site and stable appears not to be contributing much sediment to the primary arroyo. In addition, only the downstream reaches of arroyos from the north cross the vicinity of the uninhabited residence and corral.

The ground surface in Area A to the toes of the mesa slopes has been substantially altered from its natural condition by mine-related activities. From mine development through operations and subsequent closure, arroyos have apparently been filled or displaced; talus and colluvial deposits have been excavated and placed as fill in the mine area, and the two mine water sedimentation ponds have been partially backfilled. As a result, the present geomorphological features of this area are recent and do not reflect either the original, natural or likely future conditions that could alter the existing terrain.

Considering the active headcutting that is occurring in the tributaries extending to the north from the primary arroyo in Area A, it is likely that additional headcutting would eventually occur to the north into and through the mine waste rock and sedimentation ponds, unless drainage is diverted or erosion protection is applied to stabilize surfaces. Figure 4-2 depicts these tributaries.

Vegetation patterns and surficial soils on ground surfaces between arroyos, Area A, and the mesa slopes appear to be geomorphologically stable. Although a substantial thickness of Quaternary eolian sand is interbedded with alluvium in the southern part of Area A and along the primary arroyo, no dune fields or deflation basins were identified on the ground surface of Areas A, B or C. Therefore, wind scour and deposition do not appear to be active on the site.

The project area offers potential repositories for mine-related materials in both Areas A and C. The locations of potential repositories in these areas are in the vadose zone, eliminating concern about 1) groundwater infiltration into mine-related materials and 2) the leaching of its constituents into shallow aquifers. In addition, the Mancos Shale provides an excellent containment medium and source of earthen materials from which durable, low permeability covers can be constructed. Furthermore, erosional equilibrium generally occurs over the project area. Erosion and sedimentation occur in predictable segments of arroyos, except where mining has disturbed natural geomorphic processes. Potential repository sites can be sited away from arroyos, and those disturbed by mining can be restored. Finally, there are limited watershed areas upstream of Areas A and C. Both areas are near the upstream end of the watersheds of the arroyos, limiting the potential amount of runoff available as sheet and channelized flows that could contribute to erosion.

It should be noted that engineering evaluations; e.g. watershed runoff analysis, flood routing, and erosion rates are needed as part of an EE/CA to quantify and compare the attributes of the potential repository locations.

### 4.1.3 Radiological

This section is divided into discussions of the gamma count rates observed across the project area and BRA. The correlation between gamma count and exposure rates then is addressed, followed by the static gamma count rate survey of Area A.

#### 4.1.3.1 Summary of GPS-Based Gamma Survey

***Project-Area Wide***

Table 4-1 presents a statistical summary of the project-area wide gamma survey. Gamma count rates range from 5,371 to 786,801, averaging 19,357 c min$^{-1}$. There were 57,226 observations, with a standard deviation of 30,302 c min$^{-1}$.

The data set is best described using non-parametric statistics, after failing tests for normality and lognormality, using Minitab Version 15. The median of the data set is 12,593 c min$^{-1}$ and 75 percent of the results are below 14,961 c min$^{-1}$, the third quartile.

The spatial distribution and magnitude of gamma count rates in Areas A, B and C corroborate the findings of previous GPS-based gamma surveys conducted by the EPA in 2011 (EPA, 2011) and 2012 (EPA, 2012a).

***Background reference area***

Table 4-2 presents a statistical summary of gamma count rates in the BRA. Gamma count rates range from 9,434 to 18,051, averaging 13,350 c min$^{-1}$. There are 2,957 observations, with a standard deviation of 1,137 c min$^{-1}$.

The data set passes an Anderson Darling test using Minitab Version 15, indicating it is distributed normally. Accordingly, 95 percent of the data set can be described as falling within the mean ± 2 standard deviations or, 11,076 to 15,624 c min$^{-1}$.

#### 4.1.3.2 Summary of Predicted Exposure Rates

As stated in Section 3.1.3.1, field personnel took co-located one-minute static (integrated) count rate and HPIC exposure rate measurements at ten locations representing the range of gamma count rates observed during the GPS-based gamma survey. The count rates in this data set ranged from 6,864 to 531,356 c min$^{-1}$.

Table 4-3 lists the co-located measurements and their respective geopositions.

A linear regression model predicting exposure rates in microRoentgens per hour (μR h$^{-1}$) from the gamma count rates from the paired measurements was developed using MS Excel. Figure 4-3 presents the linear regression. The predictive equation is:

$$\text{Exposure rate in } \mu R\ h^{-1} = (\text{Gamma Count Rate in c min}^{-1} \times 5*10^{-4}) + 7.7$$

The model provides a strong prediction of exposure rates, with an $R^2$ of 0.9996.

***Project-Area Wide***

Table 4-4 presents a statistical summary of the set of exposure rates predicted from the gamma count rate observations in the project-area wide survey. The exposure rates range from 10.4 to 401.1, averaging 17.4 $\mu R\ h^{-1}$. There are 57,226 observations, with a standard deviation of 15.2 $\mu R\ h^{-1}$. The predicted exposure rates are best described by the median (14.0 $\mu R\ h^{-1}$) and quartiles, given that the distribution from which they are based is non-parametric. The first and third quartiles are 13.1 and 15.2 $\mu R\ h^{-1}$, respectively.

Figure 4-4 depicts the project area-wide predicted exposure rates, produced using a raster-based interpolation feature in ArcGIS.

Background (dark blue) in the figure is the exposure rate (15.5 $\mu R\ h^{-1}$) predicted from 15,624 c $min^{-1}$; the upper 95 confidence limit (mean plus two standard deviations) gamma count rate observed in the BRA. Dark blue grades into light blue and green as exposure rates increase. An area with exposure rates exceeding 16.1 $\mu R\ h^{-1}$ extends to the west from Area A onto Areas B and C, following the primary arroyo and broadening onto the eastern part of Section 13. The magnitude of exposure rates decreases away from Area A, consistent with waterborne, man-made and/or airborne patterns of distribution. Elevated exposure rates from the pipeline (remaining pipe segments and associated soil containing mine-related materials) are evident in the center and southwest portions of Area C. These areas are likely to be associated with pipeline junction boxes and discharge points.

Elevated count rates appear to be associated with mine-related materials throughout the project area. Count rates do not appear to increase near rock outcrops in any portion of the project area, indicating that there is no significant radiological mineralization therein.

***Background reference area***

Table 4-5 presents a statistical summary of exposure rates in the BRA, which range from 12.4 to 16.7, averaging 14.4 $\mu R\ h^{-1}$. There were 2,957 observations, with a standard deviation of 0.6 $\mu R\ h^{-1}$.

#### 4.1.3.3 Summary of Static Count Rates in Area A

This section presents the locations and results of the static unshielded and shielded gamma measurements taken in Area A. It includes discussions of gamma shine and mineralized outcrops. It ends with a comparison of the responses of the two detectors used in the survey.

The results were assessed by determining basic statistical parameters for the ratio of unshielded to shielded measurements and observing spatial trends, considering also the results of the wider GPS-based gamma survey.

***Static counts***

Static measurements were made at 226 of the 231 planned locations shown in Figure 3-2. The five locations were inaccessible, given that a portion of the western edge of the grid system was in a canyon wall.

Appendix C presents the results for the static measurements, by location and detector. The table also lists the ratio of the unshielded to shielded measurement at each location. The ratio is considered, because it is the primary parameter used to assess gamma shine.

Appendix D lists the geopositions of the static measurement locations.

Table 4-6 lists the summary statistics for the measurements, including those for the ratio of unshielded to shielded measurements. The unshielded measurements range from 17,955 to 608,831, averaging 100,228 c $min^{-1}$. The range of shielded measurements is 3,974 to 193,257, averaging 28,462 c $min^{-1}$. The range of the ratios of unshielded to shielded measurements is 2.1 to 7.9, averaging 4.2.

Table 4-7 lists the summary statistics for the measurements made for each detector. The means, medians, and ratio of unshielded to shielded measurements made are similar for each detector, even though they were used at different locations.

Figure 4-5 presents a raster-based interpolation of the ratios of unshielded to shielded measurements. The ratios are presented as graded colors ranging from blue (low ratios) to green (high ratios). Higher ratios indicate that unshielded gamma emissions are being influenced by gamma shine and are not necessarily comparable to areas where gamma shine is minimal.

These data were used to define --essentially reduce-- the areal extent of mine-related material in Area A. Section 4.4 presents the area and volume estimates.

#### 4.1.3.4 Summary of Down-hole Gamma Count Rates

This section presents the down-hole measurements made in the BRA and Areas A, B, and C.

***Background Reference Area***

Tables 4-8 and 4-9 present the results for down-hole measurements taken in the BRA using the 1-in. by 1-in. and 2-in. by 2-in. detector, respectively.

The distribution of the 2-in. by 2-in. down-hole measurements is non-parametric at 0 to 15 cm bgs and normal at 15 to 30 cm bgs. The mean plus two standard deviations cutoff value (23,546 c $min^{-1}$) for 15 to 30 cm served as the basis to which relevant down-hole measurements were compared in Areas B and C (and one boring in Area A). Section 3.4 presents the justification for this cutoff value.

The distribution of the 1-in. by 1-in. down-hole measurements is normal at 0 to 15 and 15 to 30 cm bgs. The mean plus two standard deviations cutoff value (5,211 c $min^{-1}$) for 15 to 30 cm served as the basis to which relevant down-hole measurements were compared in Areas A and C. Section 3.4 presents the justification for this cutoff value.

***Areas A, B, and C***

Appendix E lists the down-hole measurements taken in Areas A, B, and C.

### *Area A*

The Area A down-hole gamma logs are presented as figures in Section 4.4, for discussion regarding the estimated vertical extent of mine-related materials. Each of the down-hole gamma logs for the borings advanced in Area A is presented with a geotechnical log, with the exceptions of Borings AA-02, AA-04, and AA-05. The geotechnical engineer was not onsite when these locations were sampled. Symbols on the geotechnical logs in these figures are defined in the USCS as SC (clayey sand), SM (waste rock: silty sand), SP (poor graded sand), CL (clay), and OH (organic clay).

Table 4-10 lists findings for each Area A boring. The count rates exceed the cutoff value in the presence of waste rock and/or pond sediments. Count rates were below or essentially reached the cutoff value in all of the Area A borings, with the exception of AA-06 and AA-09. Count rates were below the cutoff values throughout Borings AA-02 and AA-05. AA-06 could not be advanced beyond 3.7 m bgs because of refusal. AA-09 was advanced *and* sampled to 7.3 m bgs. Refusal of the larger diameter, closed corer used to install the PVC pipe, limited the logging in AA-09 to 6.1 m bgs. Mean count rates in the Area A borings ranged from 13,352 to 181,393 c $min^{-1}$, using the 1-in. by 1-in. sodium iodide detector. Count rates in AA-02, determined using the 2-in. by 2-in. sodium iodide detector, averaged 21,154 c $min^{-1}$.

The estimated depth of mine-related materials in the Area A borings, based solely on down-hole logging, is summarized as follows:

- The range is from 0 (Borings AA-02 and AA-05) to greater than 7 m (Boring AA-09).
- The maximum is 3 m in borings located outside of the historical ponds (AA-01 through AA-05, AA-11, and AA-12).
- The maximum is greater than 7 m in borings located inside the historical ponds (AA-06 through AA-10).

### *Area B*

Table 4-11 lists findings for each Area B boring. Down-hole count rates were below the cutoff value for the 2-in. by 2-in. sodium iodide detector in all of the Area B borings. The range of mean count rates was 13,331 to 18,991 c $min^{-1}$.

Charts are not provided for the down-hole measurements taken in Area B, because the soil sample results and most of measurements were below associated background concentrations or cutoff values, respectively.

### *Area C*

Figures 4-6 through 4-11 are charts depicting the down-hole measurements in Area C and the cutoff values –depicted as a vertical line– used to estimate the depth of mine-related material in each boring. The logs depict the gamma count rates and respective cutoff value by depth.

Table 4-12 lists findings for each Area C boring. Count rates were below, or essentially reached either one of the two cutoff values in all of the Area C borings. Mean count rates in the Area C borings ranged from 19,328 to 232,111 c $min^{-1}$, using the 2-in. by 2-in. sodium iodide detector. Count rates in AC-06 and

AC-16, determined using the 1-in. by 1-in. sodium iodide detector, averaged 15,848 and 14,113 c $min^{-1}$, respectively.

The estimated depth of mine-related material in the Area C borings, based solely on down-hole logging, is summarized as follows:

- The range is 0.1 (Boring AC-09) to 1.2 m (Boring AC-07) in the cluster of Borings AC-07 through AC-11.

- The deepest level of mine-related material was 1.7 m, in Boring AC-06. This boring is located in the primary arroyo.

- The range is 0.3 to 0.6 m in the borings (AC-03 through AC-05; AC-12 through AC-14, AC-20 through AC-22) located in the arroyo on the western edge of Area C and extending onto Section 13.

- The range is 0 to 1.4 m in the borings (AC-01 and AC-02; AC-15 through AC-19; and AC-23) associated with the pipeline. The count rates were below the cutoff value in Boring AC-18. The maximum estimated depth was observed in Boring AC-17.

## 4. 2 Soil Sampling

### 4.2.1 Geotechnical

In accordance with Section 2.5 of the SAP, 18 borings were advanced in Area A, identified as the AA series. Of these, 11 were drilled and one was hand augered primarily for down-hole gamma logging and sampling for radionuclides and indicator metals. Logging and sampling of the same cores also provided geotechnical information. An additional six borings were advanced for geotechnical purposes and selectively sampled for geotechnical characterization testing. These borings are identified as the GEO-A series. Bulk samples of surficial soil (GEO-B series) also were collected from six locations in Area A. Three grab samples of rock (GEO-R series) were collected at ground surface from Areas A and C and stored for future durability testing, if needed.

Appendix F presents the logs of the borings and grab samples.

Ten of the samples from Area A (AA series) were tested for grain size distribution. Eleven samples from the GEO-A and GEO-B series were tested for soil classification. Five of these were tested for compacted (Proctor) density. Appendix G presents records of the geotechnical laboratory tests.

Visual observations in the field (e.g., mesas, arroyos) and of the cores obtained from borings confirmed that the Mancos shale is the bedrock that underlies the entire project area. Figure 4-12, based on a 1977 historical aerial photo, shows as independent lines the locations of three geotechnical cross sections, drawn to present surface and subsurface conditions through the portion of Area A that includes the ponds. Figures 4-13 through 4-15 are vertical cross sections illustrating the soil, rock, and mine-related materials; and their spatial relationships along each line.

The overlying Gallup sandstone forms the caprock of the surrounding mesas and talus at the toes of the mesas. Colluvial soils are a mixture of sediments from these two formations. Consequently, local native alluvial and colluvial soils classify as low plasticity clay (CL) and clayey sand (SC). Residual soils from the weathering of the Mancos Shale classify as low to moderate plasticity clay (CL with some clay with high plasticity [CH]) and are exposed at the ground surface near the toes of some mesas and in the bottoms of some arroyo channels. All soils were dry to slightly moist, except for the buried pond sediments. No surface or groundwater was encountered during the investigation.

Potential groundwater and surface-water quality impacts associated with mine-related material present in the project area and historic operations were evaluated by others (Itasca, 2013). The results of this evaluation are contained in Appendix I.

Mine facilities in Area A were constructed on and into the native alluvial and colluvial soil. The two mine water sedimentation ponds were constructed, apparently by cut and fill, into the native soils, then later backfilled with similar soils and waste rock. The buried pond sediments consist of up to 2.4 m of moist to wet plastic clays with organic content. The organic materials have a hydrocarbon odor. This material was sampled to evaluate additional characteristics (see Section 3.2.4). Soils, both above and below the pond sediments, are dry to slightly moist.

Mine waste rock material consists of uniform light gray, poorly graded, loose to medium, silty fine sand (SM) to sand (SP). Variable amounts of mine debris including scrap concrete, wood, and steel occur throughout the waste rock. The waste rock is non-cohesive.

The waste rock pile was originally located west of Pond 1, but was apparently re-graded and spread out. Waste rock is now distributed across 14.2 acres in Area A, from east of Pond 2 to the north of the vent shaft location, with thicknesses up to 5.2 m in and near the original waste pile and up to 1.8 m over the sedimentation ponds.

Native soils in the project area can provide suitable material from which to construct covers. Based on six tests of bulk samples, these soils have good compaction properties, with maximum dry (standard Proctor) densities of 100-110 pounds per cubic foot (pcf) at 10 to 15 percent moisture for CL and SC soil. The waste rock has maximum dry (standard Proctor) densities of approximately 120 pcf at 10 percent moisture. The appropriate standard for compaction, 90 percent of Standard Proctor density conducted in accordance with ASTM D-698, can be readily achieved without amendments or special equipment.

### 4.2.2 Radionuclides and Indicator Metals

Tables 4-13 and 4-14 list the soil sample results of the investigation for radionuclides and indicator metals, respectively. Note in these tables that the laboratory reported the values for uranium in units of milligrams per kilogram (mg $kg^{-1}$) but the results are reported in pCi $g^{-1}$. The concentrations were converted to pCi $g^{-1}$ by multiplying the result by a unit conversion factor of $10^6$ and 7.1x $10^{-7}$ Ci $g^{-1}$ the specific activity of natural uranium published in 49 CFR 173.434.

Sections 4.2.2.1 and 4.2.2.2 discuss the results for radionuclides and indicator metals, respectively. Section 4.2.2.3 addresses the co-location of radionuclides and indicator metals.

Appendix H presents the radionuclide and indicator metal laboratory results.

The surface and subsurface distributions of each analyte in the BRA were assessed for normality, using the Anderson-Darling test in Minitab Version 15. All of the distributions were normal, with the exception of molybdenum in BRA surface soils. The means of the respective surface (0 to 15 cm) and subsurface (15 to 30 cm) concentration of each analyte; e.g., arsenic in surface soils to arsenic in subsurface soil, were compared at a level of 95 percent confidence level, using a two sample t-test for all distributions except those of molybdenum. The distribution of the concentrations of molybdenum in surface soil is non-parametric. The medians of the surface (0 to 15 cm) and subsurface (15 to 30 cm) concentrations of molybdenum were compared at a 95 percent confidence level, using the Mann-Whitney test.

The means and median tests indicated that the surface and subsurface distributions of each of the radionuclides and indicator metals were the same. Therefore, the summary statistics presented below are based on the collective results observed for each analyte. Non-parametric statistics are provided only for molybdenum.

#### 4.2.2.1 Radionuclides

This section addresses the concentrations of radionuclides (potassium-40, radium-226, natural uranium, and isotopes of thorium (thorium-228, thorium-230, and thorium-232) in the BRA and Areas A, B, and C.

***Background Reference Area***

Table 4-15 lists summary statistics for concentrations of radionuclides in the BRA.

Potassium-40 concentrations in the BRA range from 13.9 to 17.5, and average 15.7 pCi $g^{-1}$. Radium-226 concentrations range from 0.6 to 1.2, and average 0.9 pCi $g^{-1}$. Thorium-228 concentrations range from 0.8 to 1.7, and average 1.1 pCi $g^{-1}$. Thorium-230 concentrations range from 0.6 to 1.6, and average 0.9 pCi $g^{-1}$. Thorium-232 concentrations range from 0.8 to 1.5, and average 1.0 pCi $g^{-1}$. Natural uranium concentrations range from 1.0 to 1.8, and average 1.4 pCi $g^{-1}$.

The range and average concentrations of radium-226 in the BRA are lower than those observed by the EPA (0.937 to 1.45, averaging 1.2 pCi $g^{-1}$) in its nominal background area situated in the northwest corner of Area C (EPA, 2012b).

***Area A Samples***

Table 4-16 lists summary statistics for concentrations of radionuclides in Area A.

Potassium-40 concentrations in the Area A samples range from 11.0 to 22.2, and average 16.5 pCi $g^{-1}$. Radium-226 concentrations range from 0.4 to 255, and average 62 pCi $g^{-1}$. Thorium-228 concentrations range from 0.4 to 1.8, and average 0.9 pCi $g^{-1}$. Thorium-230 concentrations range from 0.4 to 478, and average 88 pCi $g^{-1}$.Thorium-232 concentrations range from 0.4 to 1.8, and average 0.9 pCi $g^{-1}$. Natural uranium concentrations range from 0.8 to 378, and average 87 pCi $g^{-1}$.

The average concentrations of potassium-40 and thorium series radionuclides (thorium-228 and thorium-232) are similar to those observed in the BRA.

The concentrations of uranium series radionuclides: radium-226, thorium-230, and natural uranium are elevated -- when compared to the BRA-- in borings advanced through mine-related materials. The average concentrations of these radionuclides in Area A are similar. Considering that radium-226 will presumably be the indicator cleanup criterion, it is discussed herein as a surrogate for its precursors in the uranium series.

Potassium-40 concentrations in the ten samples collected in Area A in January, 2012 by the EPA ranged from 19.3 to 29, and averaged 23.1 pCi $g^{-1}$. Radium-226 concentrations in these samples ranged from 13 to 317, and averaged 144 pCi $g^{-1}$. Natural uranium concentrations ranged from 23 to 312, and averaged 198 pCi $g^{-1}$. The samples were not analyzed for thorium-228, thorium-230, and thorium-230.

The ranges and averages of the radionuclides reported by the EPA are higher than those observed in this investigation, primarily because the samples were collected from the portion of Area A that exhibited the highest gamma count rates. Any differences do not alter the conclusions in this SIR.

***Area B Samples***

Table 4-27 lists summary statistics for concentrations of radionuclides in Area B.

Potassium-40 concentrations in the Area B samples range from 12.3 to 16.4, and average 14.7 pCi $g^{-1}$. Radium-226 concentrations range from 0.5 to 1.4, and average 0.8 pCi $g^{-1}$. Thorium-228 concentrations range from 0.5 to 1.0, and average 0.7 pCi $g^{-1}$. Thorium-230 concentrations range from 0.6 to 1.6, and average 0.9 pCi $g^{-1}$.Thorium-232 concentrations range from 0.5 to 0.9, and average 0.6 pCi $g^{-1}$.Natural uranium concentrations range from 0.8 to 1.8, and average 1.1 pCi $g^{-1}$.

The means and medians are similar for each of the radionuclides and are similar to the concentrations observed in the BRA, indicating that the areas in which the Area B samples were collected are un-impacted.

The soil sample results are the primary indicator of impacts from mine-related materials. The gamma survey results --in the area where at least three of AB series of samples (AB-01, AB-02, and AB-03) were collected-- are influenced by gamma radiation from nearby Area A. The observed gamma count rates --and consequently the areal extent of mine-related materials-- in this area may be overestimates. Figure 4-5 supports this statement, considering the relatively high ratio of unshielded to shielded measurements just across the arroyo from the area in question.

The primary arroyo in this area is a physical barrier for water borne transport of mine-related materials from Area A. The volume estimates in Section 4.4 account for this observation.

***Area C Samples***

Table 4-18 lists summary statistics for concentrations of radionuclides in Area C.

Potassium-40 concentrations in the Area C samples range from 9.8 to 19.2, and average 15.3 pCi $g^{-1}$. Radium-226 concentrations range from 0.4 to 129, and average 18 pCi $g^{-1}$. Thorium-228 concentrations range from 0.4 to 1.7, and average 1.0 pCi $g^{-1}$. Thorium-230 concentrations range from 0.5 to 141, and average 13 pCi $g^{-1}$.Thorium-232 concentrations range from 0.4 to 1.5, and average 0.9 pCi $g^{-1}$.Natural uranium concentrations range from 1.0 to 203, and average 18 pCi $g^{-1}$.

### Correlation of Gamma Count Rates and Radium-226 Concentrations in Soil

As stated in Section 3.3, field personnel took one-minute static (integrated) count rate measurements at 42 of the soil sample locations.

Table 4-19 lists the measurements and their respective radium-226 concentrations in surface soils (0 to 15 cm). Equation 4-2 is the linear regression model predicting radium-226 concentrations from the gamma count rates from the paired values. Figure 4-16 presents the linear regression. The model provides a strong prediction of radium-226 concentrations, with an $R^2$ of 0.75. The predictive equation is:

Radium-226 Concentration in pCi $g^{-1}$ = ($7x10^{-4}$ x Gamma Count Rate in c $min^{-1}$) – 6.5 Eq. 4-2

The model over-predicts low radium-226 concentrations. The average of the observed gamma count rates in the BRA is 13,350 c $min^{-1}$, which predicts a radium concentration of 2.8 pCi $g^{-1}$. This is a factor of 3.1 higher than the average of the observed radium concentrations (0.9 pCi $g^{-1}$) in the BRA. Over-predictions at low radium-226 concentrations are likely due to the influence on the model from measurements associated with higher radium-226 concentrations in soil. The ability to predict radium-226 concentrations –in terms of eventual cleanup- is more important when they are at or near background levels. Soils with higher radium-226 concentrations will be more readily identified largely without the need for such a correlation.

A second linear regression model, using all of the paired values associated with radium concentrations at and below 18.2 pCi $g^{-1}$. The model, shown in Figure 4-17, provides a strong prediction of radium-226 concentrations, with an $R^2$ of 0.81. The predictive equation is:

Radium-226 Concentration in pCi $g^{-1}$ = ($4x10^{-4}$ x Gamma Count Rate in c $min^{-1}$) – 4.4 Eq. 4-3

This model predicts a radium-226 concentration of 0.9 pCi $g^{-1}$ from the average of the observed gamma count rates in the BRA (13,350 c $min^{-1}$). It under-predicts radium-226 concentrations in soil at lower count rates.

Figure 4-18 depicts the project area-wide concentrations of radium-226 predicted using Eq. 4-3, produced using a raster-based interpolation feature in ArcGIS. Background (dark blue) in the figure is the radium-226 concentration (1.8 pCi $g^{-1}$) predicted from 15,624 c $min^{-1}$; the upper 95 percent confidence limit (mean plus two standard deviations) gamma count rate observed in the BRA. Dark blue grades into light blue and green as radium-226 concentrations increase. Spatial trends in the figure are similar to those described for the predicted exposure rates depicted in Figure 4-4.

#### 4.2.2.2 Indicator Metals

#### *Background Reference Area*

Table 4-20 lists summary statistics for concentrations of indicator metals in the BRA.

Arsenic concentrations range from 4.5 to 9.2, and average 6.3 mg $kg^{-1}$. Barium concentrations range from 200 to 450, and average 372 mg $kg^{-1}$. Lead concentrations range from 10 to 17, and average 13 mg $kg^{-1}$. Selenium concentrations range from 0.37 to 0.75, and average 0.57 mg $kg^{-1}$. Vanadium concentrations range from 29 to 74, and average 44 mg $kg^{-1}$.

Molybdenum results range from 0.46 to 1.5, with a median of 0.69 mg $kg^{-1}$. The first and third quartiles of the distribution are 0.65 and 0.80 mg $kg^{-1}$.

### *Area A*

Table 4-21 lists summary statistics for concentrations of indicator metals in Area A.

Arsenic concentrations range from 1.9 to 20 and average 8.1 mg $kg^{-1}$. Barium concentrations range from 170 to 790 and average 449 mg $kg^{-1}$. Lead concentrations range from 7.5 to 23 and average 16 mg $kg^{-1}$. Molybdenum concentrations range from 0.68 to 56 and average 7.4 mg $kg^{-1}$. Selenium concentrations range from 0.2 to 68 and average 15.4 mg $kg^{-1}$. Vanadium concentrations range from 11 to 290 and average 106 mg $kg^{-1}$.

The results for indicator metals are listed by their respective Area A boring in Section 4.4.

Arsenic concentrations in the ten samples collected in Area A in January, 2012 by the EPA ranged from 4.3 to 20, and averaged 9.7 mg $kg^{-1}$. Barium concentrations in these samples ranged from 66 to 330, and averaged 130 mg $kg^{-1}$. Lead concentrations ranged from 10 to 20, and averaged 15 mg $kg^{-1}$. Molybdenum concentrations ranged from 1.3 to 22, and averaged 8.9 mg $kg^{-1}$. Selenium concentrations ranged from 1.7 to 76, and averaged 32 mg $kg^{-1}$. Vanadium concentrations ranged from 29 to 190, and averaged 110 mg $kg^{-1}$.

The ranges and averages of the arsenic, lead, molybdenum, and vanadium reported by the EPA are similar to those observed in this investigation. Barium concentrations reported by the EPA are lower than those observed in this investigation, because the EPA did not sample mine-related materials in the sediment ponds, where barium concentrations are higher, likely due to the historical barium chloride treatment conducted therein. Selenium concentrations reported by the EPA are higher than those observed in this investigation, primarily because the samples were collected from the portion of Area A that exhibited the highest amounts of mine-related materials. Any differences do not alter the conclusions in this SIR.

### *Area B*

Table 4-22 lists summary statistics for concentrations of indicator metals in Area B.

Arsenic concentrations range from 2.5 to 6.1 and average 4.0 mg $kg^{-1}$. Barium concentrations range from 360 to 500 and average 417 mg $kg^{-1}$. Lead concentrations range from 9 to 13 and average 11 mg $kg^{-1}$. Molybdenum concentrations range from 0.64 to 2.00 and average 1.09 mg $kg^{-1}$. Selenium concentrations range from 0.33 to 1.10 and average 0.51 mg $kg^{-1}$. Vanadium concentrations range from 17 to 44 and average 28 mg $kg^{-1}$.

The means and medians are similar for each of the indicator metals and are similar to the concentrations observed in the BRA, indicating that the areas in which the Area B samples were collected are un-impacted.

### *Area C*

Table 4-23 lists summary statistics for concentrations of indicator metals in Area C.

Arsenic concentrations range from 3.0 to 9.8 and average 6.5 mg $kg^{-1}$. Barium concentrations range from 290 to 560 and average 399 mg $kg^{-1}$. Lead concentrations range from 8 to 20 and average 14 mg $kg^{-1}$. Molybdenum concentrations range from 0.61 to 14 and average 2.4 mg $kg^{-1}$. Selenium concentrations range from 0.47 to 27 and average 2.5 mg $kg^{-1}$. Vanadium concentrations range from 118 to 190 and average 54 mg $kg^{-1}$.

#### 4.2.2.3 Co-Location of Radium-226, Uranium, and Indicator Metals

This section addresses the comparison of the concentrations of radium-226 to uranium and the indicator metals in the bottom plus 15 cm samples collected in Areas A and C.

The medians of the concentrations of the six indicator metals in the 30 samples collected from the BRA were tested against their respective medians in the 96 samples collected from Areas A and C, using the Mann-Whitney test. Of the set of six indicator metals, there was no significant difference in the median concentrations of arsenic and lead in the BRA and Areas A/C, confirming that these two metals are present only at background concentrations. Trends in the co-location of radium-226, uranium, and the remaining four indicator metals (barium, molybdenum, selenium, and vanadium) are discussed below.

A radium-226 concentration of 5.9 pCi $g^{-1}$ (5 pCi $g^{-1}$ plus background, the standard applied at the San Mateo Mine) is approximately five times the maximum result (1.2 pCi $g^{-1}$) observed in the BRA. Accordingly, five times the maximum concentrations of uranium and indicator metals observed in the BRA was used as a benchmark to evaluate the co-location of uranium and metals with radium in the project area.
Radium-226 concentrations are less than 5 pCi $g^{-1}$ plus background in 31 of the 34 Area A and Area C samples collected below the estimated depth of mine-related materials. Uranium and indicator metals concentrations in these samples are compared to five times their respective maximum values in the BRA as follows:

- Uranium concentrations exceed five times the maximum observed in the BRA (1.8 pCi $g^{-1}$) in two of these samples (13 pCi $g^{-1}$ in AA-07 and 11 pCi $g^{-1}$ in AC-17).

- None of the barium concentrations exceeds five times the maximum observed in the BRA (450 mg $kg^{-1}$).

- None of the molybdenum concentrations exceeds five times the maximum observed in the BRA (1.5 mg $kg^{-1}$).

- None of the selenium concentrations exceeds five times the maximum observed in the BRA (0.75 mg $kg^{-1}$).

- None of the vanadium concentrations exceeds five times the maximum observed in the BRA (74 mg $kg^{-1}$).

The results indicate that the four indicator metals and uranium are co-located with radium-226. The concentrations of uranium, molybdenum, selenium, and vanadium approach background levels in soil samples where radium-226 concentrations approach background levels.

### 4.2.3 Additional Characteristics for Pond Sediment Sample

Constituents in the sample of pond sediment were all below their respective limits in 40 CFR 261.21 (ignitability), 40 CFR 261.23 (reactive cyanide and sulfide), 40 CFR 261.22 (pH), and 40 CFR 261.24 (TCLP SVOCs and VOCs).

The laboratory analytical results for this sample are presented in Appendix H.

## 4.3 Quality Assurance/Quality Control

This section addresses Quality Assurance/Quality Control (QA/QC) and findings from the validation of the radionuclide and indicator metals data.

ALS Laboratory Group issued fully-documented (Level IV) data packages including the raw data for all analyses and electronic data deliverables (EDDs) for each of its work orders, in the form of MS Excel files. The Level IV documentation allows for validation of results against contractual requirements and allows data uses and/or limitations to be identified prior to actual use of data.

The EDDs were reviewed for completeness and correctness, prior to being loaded into an MS Access database. Data validation included a review of raw data and associated QC summary forms for compliance with the applicable methods and for data usability, in accordance with ERG Standard Operating Procedure 4.12. Data validation included a review of the following QC measures:

- Field data validation
- Holding times
- Chain-of-Custody
- Method Detection Limits
- Calibration and Internal Standards
- Laboratory Control Standards
- Laboratory Duplicate Sample Analyses
- Laboratory Blanks
- Matrix Spike Samples
- Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) Serial Dilution Analysis
- Field Duplicate Sample Analyses
- Data completeness
- Sample results verification

### *Field Data Validation*

No discrepancies were identified in the field data, with the exception of the switching of sample bags described in Section 3.7.

### *Chain-of-Custody*

Minor laboratory transcriptional errors were noted in several sample identifications. The laboratory corrected these errors in the Level IV packages.

### *Holding Times*

The timeframe of sample collection and receipt by the laboratory was within method-specific holding times, with the exception of the sample of pond sediment that was submitted for analysis of reactive cyanide, ignitability, pH, reactive sulfide, and TCLP SVOCs and VOCs. These parameters, out of the scope of the SAP, were included to evaluate potential remedies for managing the mine-related materials.

### *Method Detection Limits*

The laboratory largely met the contract-required detection limits (CRDL). There were 87 instances where results for radionuclides were flagged with "M3," indicating that the CRDL was not met, but the reported activity was greater than the reported minimum detectable concentration (MDC). Thus, the results were judged as valid.

### *Calibration and Internal Standards, Laboratory Control Standards, Laboratory Duplicate Sample Analyses*

Initial and continuing calibrations were determined to be acceptable for the ICP-MS; and alpha and gamma spectroscopy analyses. First, percent recoveries of standards were within tolerance limits. Secondly, daily and calibrations were performed for all instruments. Finally, weekly backgrounds were run for the gamma spectrometers used by the laboratory.

The results for laboratory control standards and duplicate samples were within tolerance limits.

The laboratory reported an inherent low bias to lead-214 and bismuth-214 results when using a mixed nuclide gamma source for its efficiency calibrations. The magnitude of the bias was determined to be approximately 23 percent for lead-214 and 32 percent for bismuth-214. This bias also exists for radium-226, because it was quantified using the emissions of these radionuclides. The laboratory reported all radium-226 results with a "J" qualifier.

### *Laboratory Blanks*

No contaminants were observed in the calibration and preparation blanks for the ICP-MS; and alpha and gamma spectroscopy analyses. In addition, the laboratory performed calibration blanks for at least 10 percent of the total number of samples reported.

### *Matrix Spike Samples*

The frequencies of matrix spikes were greater than 5 percent of the total number of reported samples (gamma spectroscopy analysis not included).

Spike recoveries for matrix spike samples and duplicates were within applicable method-specific control limits.

### *ICP-MS Serial Dilution Analysis*

Negative physical and/or chemical interferences were not apparent in the assessment of ICP-MS analyses.

### *Field Duplicate Sample Analyses*

Seven (5 percent) of the 136 samples collected during the investigation were replicated for QC purposes, in accordance with the SAP. Analytical precision for the indicator metals was calculated by expressing, as a percentage, the relative percent difference (RPD) between results of analyses of the duplicate samples for a given analyte. Analytical precision for the radionuclides was calculated by expressing the replicate error ratio (RER) between results of analyses of duplicate samples for a given analyte. Tables 4-28 and 4-29 list the results for the indicator metals and radionuclides, respectively.
The RPDs in Table 4-28 were determined as follows:

$$RPD = \frac{|S-R|}{\left(\frac{S+R}{2}\right)} \times 100 \qquad \text{Eq. 4-5}$$

Where:
S= sample result
R = replicate result

The RERs in Table 4-29 were determined as follows:

$$RER = \frac{|S-R|}{\sqrt{TPU_S^2+TPU_R^2}} \qquad \text{Eq. 4-6}$$

Where:
S= sample result
R = replicate result
TPU = total propagated uncertainty

SOP 4.12 states that the RPD and RER must be within the specified sampling plan control limits for sample values greater than five times the reporting limit. The SAP does not specify the control limits; however, common upper limits are an RPD of 20 and an RER of 1.

Examination of the results provided in Table 4-28 indicates that the RPDs for 11 of the 49 results exceed the tolerance limit of 20. Of the seven duplicates, one was out of tolerance for barium; two for lead, three for molybdenum, one for vanadium, and three for uranium.

All of the RERs for the field duplicates were acceptable.

Because duplicate results are generally comparable for the majority of QC samples collected and the other parameters for these pairs of soil samples were within acceptable ranges, no request to re-analyze the samples were made.

***Sample Results Verification***

Approximately 5 percent of the raw data were assessed to verify the correct calculation of sample results reported by the laboratory. There were no discrepancies between the raw and reported data.

### 4.4 Area and Volume Estimates

Figures 4-19 through 4-30 present summary information for each of the Area A borings, including the concentrations of radium-226, thorium-230, uranium and indicator metals in soils; and geotechnical logs (where applicable) superimposed on the down-hole gamma logs. The depth was estimated primarily from down-hole gamma measurements, and modified according to associated radium-226 concentrations in soil.

Figures 4-31 and 4-32 present the 21 (two of which are subdivided) shapes in which areas and volumes were estimated. The outlines of the shapes in Figure 4-31 coincide with a gamma count rate of 19,128 c $min^{-1}$; the count rate correlating to 5.9 $pCig^{-1}$ radium-226 (5 pCi $g^{-1}$ plus the average concentration observed in the BRA). The areal extent of mine-related materials in this scenario is 16 acres in Area A, 13 acres in Area B, and 65 acres in Area C.

The outlines of the shapes in Figure 4-32 coincide with a gamma count rate of 15,624 c $min^{-1}$; the average count rate in the BRA plus two standard deviations. The areal extent of mine-related materials in this scenario is 21acres in Area A, 29 acres in Area B, and 119 acres in Area C.

Table 4-24 lists the average depths used to estimate volumes in the 21 shapes, for presumed cleanups to the average background concentration of radium-226 (0.9 pCi $g^{-1}$) and 5 pCi $g^{-1}$ radium-226 plus background (5.9 pCi $g^{-1}$). The vertical extent for the former scenario is based primarily on down-hole measurements. The estimated depth for the latter scenario in Area A also was based on down-hole measurements, although modified in a few cases by radium-226 concentrations in soil samples. The estimated depth for the latter scenario in Area C was based primarily on radium-226 concentrations in soil samples.

Table 4-25 presents the volume estimate of mine-related material delineated to the 5 pCi $g^{-1}$ radium-226 plus background standard in surface soil (0 to 15 cm) used at the San Mateo Mine. The estimated volume of mine-related material in this scenario is 265,000 $m^3$ (rounded to the nearest 5,000 from 265,900 $m^3$).

Table 4-26 presents the volume estimate of mine-related material in the project area delineated to background gamma count rates. The estimated volume of mine-related material in this scenario is 450,000 $m^3$ (rounded to the nearest 5,000 from 446,800 $m^3$).

# Section 5.0 – Conclusions

The findings of the investigation are:

- The horizontal and vertical extents of potential mine-related materials were delineated sufficiently to support remedy selection and design.

- A representative BRA was established in Area B. The BRA is isolated from mine-related materials in the project area and its soil types are representative of the majority of low-lying portions of Area C.

- The estimated volume of mine-related materials using the 5 pCi $g^{-1}$ radium-226 plus background standard applied at the San Mateo Mine is 265,000 $m^3$.The estimated volume is 450,000 $m^3$, delineating to the project area background concentration of radium-226 (0.9 pCi $g^{-1}$).

- Indicator metals are sufficiently co-located with radium-226 such that radium-226 field results can be used to guide remediation.

- Any transport of mine-related material is primarily limited to runoff from Area A and sedimentation in arroyos.

- Mine-related materials in the project area are not impacting surface water or groundwater quality on or downgradient from the project area. Groundwater at the uninhabited residence on Area C is upgradient of the mine.

- Onsite (Areas A, B, and C) sources of soil cover material are adequate for in-place stabilization.

- Area A and the north-central part of Area C have geotechnical and geomorphological attributes that are suitable for location of a repository for mine-related materials.

# Section 6.0 – References

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# Tables

## Table 2-1. Summary of Scope

| Survey Method/Endpoint | Baseline Investigation Scope | Parameters Evaluated |
|---|---|---|
| A. GPS-based gamma surveys at Areas A, B, and C | Unshielded gamma readings taken over the project area at an approximate height of 0.5 m, coupled with x- and y- coordinates taken every second on 50 m transects at less than 1 m $s^{-1}$. | Gamma count rates serve as basis to estimate exposure rates, radium-226 concentrations in surface soil and identify the areal extent of any mine-related material and to provide information regarding an appropriate BRA. |
| B. Gamma measurements at fixed points in Area A. | 1-min. integrated gamma measurements made with an unshielded detector at an approximate height of 0.5 m and with a collimated (shielded) detector at 15 cm (shield on contact with the soil). All measurements taken in the centers of 225, 20 by 20 $m^2$ grids. | Shielded gamma count rates serve as basis to evaluate the areal extent of mine-related material in areas where scattered radiation (shine) may be significant. |
| C. Soil sampling of Area C | 63 samples collected at 23 locations at the following depth intervals: 0 to 15 cm, 15 cm surface to a radiological cutoff value, and an additional 15 cm below the depth corresponding to the radiological cutoff value (with exceptions).<br><br>Three samples of sandstone collected for geotechnical characterization. | Radionuclides and indicator metals for all samples. The data were used to establish the estimated depth of mine-related material. |
| D. Down-hole gamma Measurements | Down-hole gamma screening of all borings. Gamma count rate data were made at approximately 15 or 30 cm intervals at each soil sampling location. | Gamma count rates were compared to the response from the BRA. This information was used to establish the estimated depth of any mine-related material. |
| E. Soil sampling of Area A | 33 samples were collected at twelve locations at the following depth intervals: 0 to 15 cm, 15 cm surface to a radiological cutoff value, and an additional 15 cm below the estimated depth corresponding to the radiological cutoff value.<br><br>Six additional borings were advanced for supplemental geotechnical characterization (prescribed in general in SAP).<br><br>Six bulk samples were collected for supplemental geotechnical characterization (prescribed in general in SAP). | Radionuclides and indicator metals for all samples. The data were used to characterize the nature of mine-related material. |
| F. Soil sampling of Area B, including random sampling of one potential BRA. | Ten samples collected at five locations outside BRA at the following depth intervals: 0 to 15 cm, 15 cm surface to the bottom of radiological cutoff level, and an additional 15 cm below the bottom of radiological cutoff level. 30 soil samples collected from 15 locations in one BRA at depths of 0-15 cm and 15-45 cm. | Radionuclides and Indicator metals for all samples. Data were be used to establish background condition of project area. |

**Table 2-1. Summary of Scope (concluded)**

| Survey Method/Endpoint | Baseline Investigation Scope | Parameters Evaluated |
|---|---|---|
| G. Co-located exposure and gamma count rate measurements | 1-min. integrated gamma measurements taken with an unshielded detector at an approximate height of 0.5 m paired with 5-min. exposure rate measurements taken at an approximate height of 1 m. Paired measurements taken at 10 locations. | Paired measurements serve as a basis to predict site-wide exposure rates. |
| H. Co-located gamma count rate and soil sampling and analysis for radium-226 (subset of Items C, E, and F) | 1-minute integrated gamma measurements taken with an unshielded detector at an approximate height of 0.5 m paired with radium-226 concentrations at 42 sample locations. | Paired measurements serve as a basis to 1) predict site-wide radium-226 concentrations and/or 2) predict gamma count rates associated with a presumed gamma count rate action level for an associated radium-226 concentration. |
| I. Temporary stabilization measure. | A silt fence was installed in the primary arroyo, to mitigate offsite sediment transport. | None |

Notes:
BRA = BRA
cm = centimeter
GPS = Global Positioning System
m = meter
min. = minute
s = second
SAP = Site Assessment Plan

## Table 3-1. Analytical Methods for Soils

| Parameter | Method |
|---|---|
| Digestion for metals | EPA Method 3052 |
| Natural Uranium | EPA Method 6020A |
| Isotopic Thorium | ASTM 3972-2 |
| Potassium-40, Radium-226[a] | EPA 901.1 M |
| Arsenic, Barium, Lead, Molybdenum, Selenium, Vanadium | EPA Method 6020A |
| Grain size analysis: particle size distribution and Atterberg Limits | ASTM D422, D2217 |
| Liquid Limit, Plastic Limit and Plasticity Index | ASTM D4318 |
| Soil Moisture Content | ASTM D2216 |
| Laboratory Compaction | ASTM D698 |

Notes:
[a]Radium-226 concentrations determined by way of bismuth-214 surrogate.
ASTM = American Society for Testing and Materials
EPA = U.S. Environmental Protection Agency

**Table 4-1. Summary Statistics of Project-Area Wide Gamma Count Rates**

| Variable | Gamma Count Rate (c $min^{-1}$) |
|---|---|
| n | 57,226 |
| Minimum | 5,371 |
| Maximum | 786,801 |
| Mean | 19,357 |
| Median | 12,593 |
| σ | 30,302 |
| Q1 | 10,780 |
| Q3 | 14,961 |
| IQR | 4,181 |

Notes:
c $min^{-1}$ = counts per minute
IQR = interquartile range
n = number of measurements
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

**Table 4-2. Summary Statistics of Background Reference Area Gamma Count Rates**

| Variable | Gamma Count Rate (c $min^{-1}$) |
|---|---|
| n | 2,957 |
| Minimum | 9,434 |
| Maximum | 18,051 |
| Mean | 13,350 |
| Median | 13,329 |
| σ | 1,137 |
| Q1 | 12,580 |
| Q3 | 14,117 |
| IQR | 1,537 |

Notes:
c $min^{-1}$ = counts per minute
IQR = interquartile range
n = number of measurements
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

## Table 4-3. Co-located Gamma Count and Exposure Rate Measurements

| Location | Easting (ft)[a] | Northing (ft)[a] | Gamma Count Rate (c $min^{-1}$) | Exposure Rate (μR $hr^{-1}$) |
|---|---|---|---|---|
| PIC-01 | 2755788.2 | 1587606.7 | 278425 | 145.14 |
| PIC-02 | 2755725.5 | 1587304.7 | 531356 | 275.21 |
| PIC-03 | 2755533.9 | 1586640.5 | 78646 | 43.92 |
| PIC-04 | 2755317.5 | 1588571.4 | 6864 | 11.61 |
| PIC-05 | 2757432.7 | 1586744.2 | 9551 | 13.56 |
| PIC-06 | 2755130.1 | 1586672.1 | 164901 | 90.33 |
| PIC-07 | 2755085.9 | 1586541.4 | 63996 | 39.43 |
| PIC-08 | 2754446.1 | 1586049.1 | 43641 | 31.23 |
| PIC-09 | 2753342.9 | 1585620.2 | 24079 | 21.20 |
| PIC-10 | 2755089.1 | 1586736.9 | 116714 | 65.56 |

Notes:
[a] Coordinate system is NAD1983, New Mexico West.
c $min^{-1}$ = counts per minute
ft = feet
μR $h^{-1}$ = microRoentgens per hour

## Table 4-4. Summary Statistics of Project Area-Wide Predicted Exposure Rates

| Variable | Exposure μR $h^{-1}$ |
|---|---|
| n | 57,226 |
| Minimum | 10.4 |
| Maximum | 401.1 |
| Mean | 17.4 |
| Median | 14.0 |
| σ | 15.2 |
| Q1 | 13.1 |
| Q3 | 15.2 |
| IQR | 2.1 |

Notes:
IQR = interquartile range
μR $h^{-1}$ = microRoentgens per hour
n = number of measurements
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

**Table 4-5. Summary Statistics of Predicted Exposure Rates in Background Reference Area**

| Variable | Exposure μR $h^{-1}$ |
|---|---|
| N | 2957 |
| Minimum | 12.4 |
| Maximum | 16.7 |
| Mean | 14.4 |
| Median | 14.4 |
| σ | 0.6 |
| Q1 | 14.0 |
| Q3 | 14.8 |
| IQR | 0.8 |

Notes:
IQR = interquartile range
μR $h^{-1}$ = microRoentgens per hour
n = number of measurements
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

**Table 4-6. Summary Statistics for Static mineasurements in Area A**

| Parameter | Unshielded Measurement (c $min^{-1}$) | Shielded Measurement (c $min^{-1}$) | Ratio of Unshielded to Shielded Measurements |
|---|---|---|---|
| n | 226 | 226 | 226 |
| Mean | 100228 | 28462 | 4.2 |
| Minimum | 17955 | 3974 | 2.1 |
| Maximum | 608831 | 193257 | 7.9 |
| σ | 90183 | 30950 | 1.0 |

Notes:
n = number of measurements
c $min^{-1}$ = counts per minute
σ = standard deviation

**Table 4-7. Summary Statistics for Detector Used in Static mineasurements in Area A**

| | Unshielded Measurements ($c\ min^{-1}$) | | Shielded Measurements ($c\ min^{-1}$) | | Ratio[a] | |
|---|---|---|---|---|---|---|
| **Detection System** | **1[b]** | **2[c]** | **1[b]** | **2[c]** | **1[b]** | **2[c]** |
| n | 113 | 113 | 113 | 113 | 113 | 113 |
| Median | 69822 | 74855 | 17263 | 16176 | 3.8 | 4.3 |
| Mean | 100336 | 100119 | 29892 | 27032 | 4.0 | 4.5 |
| Minimum | 19307 | 17955 | 4667 | 3974 | 2.1 | 2.3 |
| Maximum | 481245 | 608831 | 174822 | 193257 | 6.5 | 7.9 |
| σ | 88121 | 92591 | 31768 | 30182 | 0.9 | 1.1 |

Notes:
[a] Ratio of unshielded to shielded measurement.
[b] Detector serial numbers are 254772 (Ludlum Model 2221) and PR118372 (Ludlum Model 44-10)
[c] Detector serial numbers are 254757 (Ludlum Model 2221) and PR199131 (Ludlum Model 44-10)
$c\ min^{-1}$ = counts per minute
n = number of measurements
σ = standard deviation

**Table 4-8. Down-hole and Associated Surface Measurements in the Background Reference Area: 2-in. by 2-in. Detector**

| | Unshielded Measurement (c min$^{-1}$) | |
|---|---|---|
| **Location** | **0-15 cm bgs** | **15-30 cm bgs** |
| BRA-01 | 16306 | 17778 |
| BRA-02 | 15681 | 17540 |
| BRA-03 | 21373 | 23306 |
| BRA-04 | 15766 | 18073 |
| BRA-05 | 15956 | 20229 |
| BRA-06 | 17045 | 18412 |
| BRA-07 | 16635 | 20075 |
| BRA-08 | 18151 | 22445 |
| BRA-09 | 19801 | 22222 |
| BRA-10 | 17643 | 19529 |
| BRA-11 | 15709 | 17108 |
| BRA-12 | 15707 | 19641 |
| BRA-13 | 16412 | 20290 |
| BRA-14 | 15870 | 20101 |
| BRA-15 | 15070 | 16818 |
| **Mean** | **16875** | **19571** |
| **σ** | **1735** | **1987** |
| **Mean + 2σ** | **20344** | **23546** |

Notes:
bgs = below ground surface
c min$^{-1}$ = counts per minute
cm = centimeter
σ = standard deviation

**Table 4-9. Down-hole and Associated Surface Measurements in the Background Reference Area: 1-in. by 1-in. Detector**

| | Unshielded Measurement (c min$^{-1}$) | |
|---|---|---|
| **Location** | **0-15 cm bgs** | **15-30 cm bgs** |
| BRA-01 | 3361 | 3972 |
| BRA-02 | 3266 | 3486 |
| BRA-03 | 4623 | 5256 |
| BRA-04 | 3577 | 4544 |
| BRA-05 | 4164 | 4240 |
| BRA-06 | 3583 | 4065 |
| BRA-07 | 3989 | 4722 |
| BRA-08 | 3893 | 4168 |
| BRA-09 | 4712 | 4818 |
| BRA-10 | 3935 | 4271 |
| BRA-11 | 3366 | 4044 |
| BRA-12 | 3471 | 4061 |
| BRA-13 | 3888 | 4750 |
| BRA-14 | 3797 | 4247 |
| BRA-15 | 3272 | 3681 |
| **Mean** | **3793** | **4288** |
| **σ** | **452** | **461** |
| **Mean + 2 σ** | **4697** | **5211** |

Notes:
bgs = below ground surface
c min$^{-1}$ = counts per minute
cm = centimeter
σ = standard deviation

**Table 4-10. Summary of Down-hole Measurements in Area A (Borings AA-01 through AA-12)**

| | Gamma Count Rate (c min$^{-1}$) | | | | |
|---|---|---|---|---|---|
| **Location** | **Minimum** | **Maximum** | **Mean** | **Depth to Cutoff Value (m)** | **Observations** |
| AA-01 | 2894 | 89491 | 15490 | 1.3 | Elevated count rates associated with waste rock |
| AA-02[a] | 19984 | 22323 | 21154 | 0 | No readings above cutoff value observed |
| AA-03 | 5795 | 307397 | 74438 | 2.0 | Elevated count rates associated with waste rock |
| AA-04 | 3713 | 67906 | 13352 | 3.0 | Elevated count rates associated with waste rock |
| AA-05 | 1909 | 3475 | 2478 | 0 | No readings above cutoff value observed |
| AA-06 | 14333 | 376301 | 71433 | >3 | Elevated count rates associated with waste rock and, potentially, sediments. Encountered refusal at 3.7 m bgs |
| AA-07 | 7172 | 709585 | 181393 | 4.2 | Elevated count rates associated with waste rock and pond sediments |
| AA-08 | 4307 | 612707 | 152424 | 6.0 | Elevated count rates associated with waste rock and pond sediments |
| AA-09 | 20163 | 548734 | 178407 | >7 | Elevated count rates associated with waste rock and pond sediments. The base of the boring was 7.3 m bgs. Field personnel logged 6.1 m bgs, given that only this length of PVC could be installed in the boring. |
| AA-10 | 4156 | 253157 | 130031 | 4.3 | Elevated count rates associated with waste rock and pond sediments |
| AA-11 | 4706 | 69876 | 23600 | 1.9 | Elevated count rates associated with waste rock |
| AA-12 | 6235 | 192018 | 32584 | 1.7 | Elevated count rates associated with waste rock |

Notes:
[a] Measurements taken using a 2-in. by 2-in. sodium iodide detector
bgs = below ground surface
c min$^{-1}$ = counts per minute
m = meter

## Table 4-11. Summary of Down-hole Measurements in Area B (Borings AB-01 through AB-05)

| | Gamma Count Rate (c $min^{-1}$) | | | | |
|---|---|---|---|---|---|
| **Location** | **Minimum** | **Maximum** | **Mean** | **Depth to Cutoff Value (m)** | **Observations** |
| AB-01 | 12708 | 13953 | 13331 | 0 | No gamma count rates above cutoff value observed |
| AB-02 | NA | NA | NA | NA | Rocky soils, hand auger refused. |
| AB-03 | 12967 | 14207 | 13587 | 0 | No gamma count rates above cutoff value observed |
| AB-04 | 16552 | 20108 | 18330 | 0 | No gamma count rates above cutoff value observed |
| AB-05 | 16865 | 21117 | 18991 | 0 | No gamma count rates above cutoff value observed |

Notes:
c $min^{-1}$ = counts per minute
m = meter
NA = not applicable

## Table 4-12. Summary of Down-hole Measurements in Area C (Borings AC-01 through AC-23)

| | Gamma Count Rate (c min$^{-1}$) | | | | |
|---|---|---|---|---|---|
| Location | Minimum | Maximum | Mean | Depth to Cutoff Value (m) | Observations |
| AC-01 | 23239 | 72115 | 38379 | 0.5 | Surface only |
| AC-02 | 23387 | 101861 | 45525 | 0.6 | Surface only |
| AC-03 | 23370 | 28084 | 25011 | 0.3 | Surface only |
| AC-04 | 20190 | 35285 | 26427 | 0.4 | Surface only |
| AC-05 | 19320 | 70356 | 37980 | 0.4 | Surface only |
| AC-06[a] | 6232 | 25293 | 15848 | 1.7 | Arroyo location, increasing count rates with depth, then a decline to the cutoff value. |
| AC-07 | 23168 | 926103 | 232111 | 1.2 | Increasing count rates with depth, then a decline to the cutoff value. |
| AC-08 | 27090 | 188763 | 65233 | 0.6 | Surface only |
| AC-09 | 16963 | 21842 | 19328 | 0.12 | Surface only |
| AC-10 | 24120 | 255899 | 67158 | 0.1 | Surface only |
| AC-11 | 17368 | 49834 | 36466 | 0.6 | Increasing count rates with depth, then a decline to the cutoff value. |
| AC-12 | 22863 | 32576 | 26469 | 0.3 | Increasing count rates with depth, then a decline to the cutoff value. |
| AC-13 | 21969 | 41143 | 29154 | 0.5 | Surface only |
| AC-14 | 17366 | 40014 | 27021 | 0.4 | Surface only |
| AC-15 | 28156 | 469064 | 164281 | 1.05 | Pipeline location. Increasing count rates with depth, then a decline to the cutoff value. |
| AC-16[a] | 5460 | 30805 | 14113 | 0.6 | Pipeline location. Increasing count rates with depth, then a decline to the cutoff value. |
| AC-17 | 28322 | 677860 | 205885 | 1.35 | Pipeline location. Increasing count rates with depth, then a decline to the cutoff value. |
| AC-18 | 21500 | 22912 | 22217 | 0 | No readings above cutoff value observed |
| AC-19 | 22062 | 112372 | 46212 | 0.4 | Surface only |
| AC-20 | 21074 | 68638 | 37986 | 0.6 | Increasing count rates with depth, then a decline to the cutoff value. |
| AC-21 | 20025 | 100319 | 51753 | 0.6 | Surface only |
| AC-22 | 20112 | 37495 | 26995 | 0.3 | Surface only |
| AC-23 | 25123 | 33274 | 29199 | 0.3 | Surface only |

Notes:
[a] Measurement taken using 1-in. by 1-in. sodium iodide detector
c min$^{-1}$ = counts per minute
m = meter

## Table 4-13. Soil Sample Results: Radionuclides

| Sample ID | Date Collected | Potassium-40 (pCi g-1) Result | Potassium-40 PRL | Potassium-40 TPU | Radium-226 (pCi g-1) Result | Radium-226 PRL | Radium-226 TPU | Thorium-228 (pCi g-1) Result | Thorium-228 PRL | Thorium-228 TPU | Thorium-230 (pCi g-1) Result | Thorium-230 PRL | Thorium-230 TPU | Thorium-232 (pCi g-1) Result | Thorium-232 PRL | Thorium-232 TPU | Uranium (pCi g-1) Result | Uranium PRL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AA-01-0015-101512 | 10/15/2012 | 15.2 | 2.8 | 2.6 | 129 | 0 | 15 | 0.72 | 0.11 | 0.16 | 76 | 0 | 12 | 0.81 | 0.04 | 0.16 | 322 | 0.01 |
| AA-01-15115-10152 | 10/15/2012 | 16.8 | 0.5 | 2.2 | 3.17 | 0.11 | 0.38 | 1.31 | 0.08 | 0.24 | 2.02 | 0.09 | 0.35 | 1.35 | 0.02 | 0.24 | 7.7 | 0.008 |
| AA-01-115145-101512 | 10/15/2012 | 12.6 | 0.9 | 2.1 | 1.23 | 0.12 | 0.17 | 0.52 | 0.1 | 0.12 | 0.49 | 0.1 | 0.12 | 0.49 | 0.02 | 0.1 | 0.8 | 0.01 |
| AA-02-SS-0015-101112 | 10/11/2012 | 16.6 | 0.4 | 2.2 | 1.13 | 0.07 | 0.14 | 1.52 | 0.1 | 0.27 | 1.27 | 0.09 | 0.23 | 1.35 | 0.03 | 0.24 | 1.8 | 0.01 |
| AA-02-SS-1530-101112 | 10/11/2012 | 15.5 | 0.3 | 2 | 1.06 | 0.07 | 0.14 | 1.46 | 0.09 | 0.28 | 1.04 | 0.12 | 0.21 | 1.15 | 0.01 | 0.22 | 1.7 | 0.0069 |
| AA-03-SS-0015-101512 | 10/15/2012 | 14.5 | 2.9 | 2.6 | 244 | 0 | 29 | 1.21 | 0.09 | 0.22 | 282 | 0 | 44 | 0.82 | 0.02 | 0.15 | 308 | 0.01 |
| AA-03-SS-15145-101512 | 10/15/2012 | 16 | 2.1 | 2.4 | 129 | 0 | 15 | 1.25 | 0.09 | 0.23 | 126 | 0 | 20 | 0.92 | 0.02 | 0.17 | 266 | 0.008 |
| AA-03-SS-145235-101512 | 10/15/2012 | 18 | 0.6 | 2.6 | 1.66 | 0.1 | 0.21 | 1.2 | 0.08 | 0.22 | 0.94 | 0.09 | 0.18 | 1.14 | 0.02 | 0.2 | 4.1 | 0.008 |
| AA-04-SS-0015-102212 | 10/22/2012 | 17.7 | 1.9 | 2.6 | 112 | 0 | 13 | 0.93 | 0.08 | 0.17 | 120 | 0 | 19 | 0.84 | 0.02 | 0.15 | 378 | 0.01 |
| AA-04-SS-15205-102212 | 10/22/2012 | 16.5 | 1 | 2.3 | 20.6 | 0.2 | 2.4 | 0.384 | 0.062 | 0.086 | 11.2 | 0.1 | 1.7 | 0.385 | 0.015 | 0.078 | 8 | 0.008 |
| AA-04-SS-205300-102212 | 10/22/2012 | 17.2 | 0.7 | 2.5 | 2.07 | 0.11 | 0.26 | 0.97 | 0.11 | 0.19 | 1.15 | 0.09 | 0.22 | 0.99 | 0.01 | 0.18 | 2.3 | 0.008 |
| AA-05-SS-0015-102212 | 10/22/2012 | 14 | 0.4 | 1.9 | 2.43 | 0.09 | 0.3 | 0.5 | 0.08 | 0.11 | 2.32 | 0.08 | 0.39 | 0.57 | 0.02 | 0.11 | 1.8 | 0.0068 |
| AA-05-SS-15230-101612 | 10/16/2012 | 11 | 0.6 | 1.7 | 0.395 | 0.078 | 0.065 | 0.353 | 0.085 | 0.091 | 0.43 | 0.08 | 0.1 | 0.398 | 0.027 | 0.085 | 0.9 | 0.0068 |
| AA-06-SS-0015-101612 | 10/16/2012 | 17 | 1.7 | 2.5 | 63.1 | 0.3 | 7.4 | 0.74 | 0.1 | 0.16 | 35.3 | 0.1 | 5.5 | 0.67 | 0.02 | 0.13 | 37 | 0.008 |
| AA-06-SS-15355-101612 | 10/16/2012 | 15.6 | 0.7 | 2.1 | 15.1 | 0.2 | 1.8 | 0.61 | 0.32 | 0.25 | 50 | 0.2 | 8.5 | 0.68 | 0.1 | 0.19 | 29 | 0.01 |
| AA-07-SS-0015-101612 | 10/16/2012 | 16.9 | 1.5 | 2.4 | 77.7 | 0.3 | 9.1 | 0.96 | 0.1 | 0.19 | 63.1 | 0.1 | 9.8 | 0.73 | 0.02 | 0.14 | 182 | 0.008 |
| AA-07-SS-15415-101612 | 10/16/2012 | 18.3 | 3.9 | 3.4 | 255 | 1 | 30 | 1.58 | 0.08 | 0.28 | 405 | 0 | 63 | 1.48 | 0.01 | 0.26 | 273 | 0.008 |
| AA-07-SS-415505-101612 | 10/16/2012 | 19.3 | 0.6 | 2.6 | 1.4 | 0.11 | 0.18 | 1.81 | 0.08 | 0.31 | 1.31 | 0.08 | 0.23 | 1.83 | 0.02 | 0.31 | 13 | 0.009 |
| AA-08-SS-0015-101612 | 10/16/2012 | 18.2 | 1.5 | 2.5 | 58.3 | 0.3 | 6.8 | 0.67 | 0.07 | 0.13 | 44.9 | 0.1 | 6.9 | 0.69 | 0.03 | 0.13 | 38 | 0.01 |
| AA-08-SS-15565-101612 | 10/16/2012 | 18.5 | 1.5 | 2.6 | 71.9 | 0.3 | 8.4 | 0.68 | 0.08 | 0.14 | 44.2 | 0.1 | 6.9 | 0.59 | 0.03 | 0.12 | 50 | 0.01 |
| AA-08-SS-565795-101612 | 10/16/2012 | 17.9 | 0.4 | 2.4 | 2.14 | 0.1 | 0.26 | 1.66 | 0.09 | 0.3 | 1.9 | 0.09 | 0.33 | 1.55 | 0.01 | 0.27 | 2.4 | 0.008 |
| AA-09-SS-0015-101612 | 10/16/2012 | 18.5 | 2.3 | 2.8 | 108 | 0 | 13 | 0.65 | 0.1 | 0.14 | 96 | 0 | 15 | 0.66 | 0.01 | 0.13 | 98 | 0.008 |
| AA-09-SS-15750-101612 | 10/16/2012 | 17.8 | 1.7 | 2.5 | 120 | 0 | 14 | 0.56 | 0.09 | 0.12 | 110 | 0 | 17 | 0.72 | 0.03 | 0.14 | 133 | 0.008 |
| AA-09-SS-750950-101612 | 10/16/2012 | 22.2 | 0.6 | 2.9 | 2.82 | 0.12 | 0.35 | 1.75 | 0.07 | 0.31 | 3.88 | 0.1 | 0.64 | 1.71 | 0.02 | 0.3 | 3 | 0.008 |
| AA-10-SS-0015-101512 | 10/15/2012 | 18.1 | 1.9 | 2.6 | 134 | 0 | 16 | 0.6 | 0.08 | 0.13 | 124 | 0 | 19 | 0.68 | 0.02 | 0.13 | 231 | 0.0069 |
| AA-10-SS-15415-101512 | 10/15/2012 | 17.5 | 2.2 | 2.6 | 130 | 0 | 15 | 0.76 | 0.08 | 0.15 | 104 | 0 | 16 | 0.87 | 0.02 | 0.16 | 60 | 0.008 |
| AA-10-SS-415525-101512 | 10/15/2012 | 16.3 | 0.4 | 2.2 | 0.88 | 0.07 | 0.12 | 0.99 | 0.08 | 0.19 | 0.76 | 0.09 | 0.15 | 0.87 | 0.03 | 0.16 | 1.6 | 0.008 |
| AA-11-SS-0015-101512 | 10/15/2012 | 15.5 | 1.4 | 2.2 | 47.3 | 0.2 | 5.5 | 0.87 | 0.09 | 0.17 | 463 | 0 | 72 | 0.91 | 0.01 | 0.17 | 66 | 0.0067 |
| AA-11-SS-15145-101512 | 10/15/2012 | 12.8 | 1.6 | 2 | 33.2 | 0.3 | 3.9 | 0.7 | 0.09 | 0.14 | 37 | 0.1 | 5.8 | 0.58 | 0.02 | 0.12 | 84 | 0.0069 |

## Table 4-13. Soil Sample Results: Radionuclides (continued)

| | | Potassium-40 (pCi $g^{-1}$) | | | Radium-226 (pCi $g^{-1}$) | | | Thorium-228 (pCi $g^{-1}$) | | | Thorium-230 (pCi $g^{-1}$) | | | Thorium-232 (pCi $g^{-1}$) | | | Uranium (pCi $g^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL |
| AA-11-SS-145245-101512 | 10/15/2012 | 13.4 | 0.4 | 1.8 | 0.84 | 0.06 | 0.11 | 0.8 | 0.08 | 0.16 | 0.75 | 0.08 | 0.15 | 0.69 | 0.03 | 0.13 | 1.9 | 0.0069 |
| AA-12-SS-0015-101512 | 10/15/2012 | 17.8 | 2.5 | 2.8 | 194 | 0 | 23 | 1.08 | 0.67 | 0.49 | 478 | 1 | 73 | 1.47 | 0.21 | 0.39 | 175 | 0.008 |
| AA-12-SS-15115-101512 | 10/15/2012 | 16 | 2 | 2.5 | 79.6 | 0.3 | 9.3 | 0.75U | 0.76 | 0.5 | 198 | 1 | 31 | 1.38 | 0.15 | 0.37 | 64 | 0.008 |
| AA-12-SS-115245-101512 | 10/15/2012 | 16.1 | 0.7 | 2.2 | 7.02 | 0.11 | 0.83 | 0.65 | 0.1 | 0.14 | 32.3 | 0.1 | 5 | 0.76 | 0.02 | 0.14 | 25 | 0.0069 |
| AB-01-SS-0015-101112 | 10/11/2012 | 12.8 | 0.6 | 1.8 | 0.8 | 0.08 | 0.11 | 0.54 | 0.09 | 0.12 | 0.98 | 0.09 | 0.19 | 0.5 | 0.04 | 0.1 | 1.3 | 0.0068 |
| AB-01-SS-1530-101112 | 10/11/2012 | 12.3 | 0.3 | 1.6 | 0.486 | 0.049 | 0.068 | 0.58 | 0.09 | 0.13 | 0.69 | 0.09 | 0.14 | 0.5 | 0.04 | 0.11 | 0.8 | 0.0069 |
| AB-02-SS-0015-101112 | 10/11/2012 | 16.1 | 0.4 | 2.1 | 1.44 | 0.08 | 0.18 | 0.6 | 0.1 | 0.13 | 1.58 | 0.09 | 0.28 | 0.5 | 0.04 | 0.11 | 1.3 | 0.01 |
| AB-02-SS-1530-101112 | 10/11/2012 | 16.1 | 0.3 | 2.1 | 0.81 | 0.07 | 0.11 | 0.57 | 0.08 | 0.13 | 0.72 | 0.09 | 0.15 | 0.46 | 0.03 | 0.1 | 1.0 | 0.0068 |
| AB-03-SS-0015-101112 | 10/11/2012 | 13.3 | 0.4 | 1.8 | 0.617 | 0.072 | 0.087 | 0.59 | 0.09 | 0.13 | 0.55 | 0.08 | 0.12 | 0.55 | 0.02 | 0.11 | 0.8 | 0.0069 |
| AB-03-SS-1530-101112 | 10/11/2012 | 12.8 | 0.3 | 1.7 | 0.563 | 0.068 | 0.08 | 0.61 | 0.1 | 0.13 | 0.59 | 0.09 | 0.13 | 0.62 | 0.03 | 0.12 | 0.8 | 0.0067 |
| AB-04-SS-0015-101112 | 10/11/2012 | 16.3 | 0.3 | 2.2 | 1.14 | 0.08 | 0.15 | 0.93 | 0.11 | 0.19 | 0.99 | 0.1 | 0.2 | 0.9 | 0.02 | 0.17 | 1.5 | 0.0068 |
| AB-04-SS-1530-101112 | 10/11/2012 | 15.3 | 0.6 | 2.1 | 0.86 | 0.09 | 0.12 | 0.99 | 0.13 | 0.21 | 0.83 | 0.11 | 0.18 | 0.9 | 0.04 | 0.18 | 1.8 | 0.01 |
| AB-05-SS-0015-101112 | 10/11/2012 | 15.5 | 0.3 | 2 | 0.84 | 0.07 | 0.11 | 0.69 | 0.09 | 0.14 | 0.82 | 0.08 | 0.16 | 0.74 | 0.02 | 0.14 | 1.1 | 0.0069 |
| AB-05-SS-1530-101112 | 10/11/2012 | 16.4 | 0.5 | 2.2 | 0.88 | 0.08 | 0.12 | 0.79 | 0.08 | 0.15 | 0.87 | 0.08 | 0.17 | 0.72 | 0.03 | 0.14 | 1.1 | 0.0069 |
| AC-01-SS-0015-100912 | 10/9/2012 | 15.9 | 1.4 | 2.3 | 39.9 | 0.2 | 4.7 | 1.16 | 0.08 | 0.21 | 6.9 | 0.1 | 1.1 | 1 | 0.04 | 0.18 | 5.5 | 0.0067 |
| AC-01-SS-1530-100912 | 10/9/2012 | 17.6 | 0.5 | 2.3 | 3.45 | 0.09 | 0.41 | 1.46 | 0.19 | 0.31 | 1.59 | 0.14 | 0.32 | 1.48 | 0.09 | 0.29 | 6.4 | 0.01 |
| AC-01-SS-3045-100912 | 10/9/2012 | 16.7 | 0.4 | 2.3 | 1.67 | 0.09 | 0.21 | 1.15 | 0.12 | 0.22 | 0.92 | 0.09 | 0.18 | 1.19 | 0.03 | 0.22 | 4.1 | 0.0069 |
| AC-02-SS-0015-100912 | 10/10/2012 | 17.6 | 1.6 | 2.5 | 55.9 | 0.3 | 6.5 | 1.03 | 0.15 | 0.22 | 6.1 | 0.1 | 1 | 0.96 | 0.01 | 0.19 | 7 | 0.01 |
| AC-02-SS-1560-100912 | 10/10/2012 | 16.5 | 0.4 | 2.2 | 1.59 | 0.08 | 0.2 | 0.96 | 0.1 | 0.18 | 0.88 | 0.09 | 0.17 | 0.96 | 0.01 | 0.18 | 6.6 | 0.0068 |
| AC-02-SS-6075-100912 | 10/10/2012 | 16.5 | 0.4 | 2.2 | 1.28 | 0.08 | 0.16 | 1.08 | 0.12 | 0.21 | 0.81 | 0.1 | 0.17 | 1.17 | 0.03 | 0.22 | 8 | 0.0069 |
| AC-03-SS-0015-100912 | 10/9/2012 | 14.4 | 1.1 | 2.1 | 6.76 | 0.14 | 0.8 | 0.92 | 0.06 | 0.18 | 9.6 | 0.1 | 1.5 | 0.94 | 0.02 | 0.18 | 12 | 0.0068 |
| AC-03-SS-1530-100912 | 10/9/2012 | 16 | 0.5 | 2.1 | 1.68 | 0.08 | 0.21 | 1.12 | 0.1 | 0.21 | 1.04 | 0.09 | 0.19 | 1.15 | 0.03 | 0.21 | 2.0 | 0.0067 |
| AC-04-SS-0015-100912 | 10/19/2012 | 12.4 | 0.6 | 1.7 | 9.3 | 0.1 | 1.1 | 0.73 | 0.08 | 0.14 | 5.52 | 0.08 | 0.88 | 0.67 | 0.03 | 0.13 | 5.0 | 0.0069 |
| AC-04-SS-1530-100912 | 10/19/2012 | 12.8 | 0.5 | 1.8 | 2.52 | 0.07 | 0.31 | 0.59 | 0.08 | 0.12 | 1.55 | 0.08 | 0.27 | 0.5 | 0.03 | 0.1 | 3.8 | 0.0069 |
| AC-04-SS-3045-100912 | 10/19/2012 | 12.6 | 0.7 | 1.8 | 1.86 | 0.09 | 0.24 | 0.65 | 0.06 | 0.13 | 1.21 | 0.07 | 0.21 | 0.57 | 0 | 0.11 | 4.0 | 0.0069 |
| AC-05-SS-0015-100912 | 10/9/2012 | 15 | 0.8 | 2 | 18.2 | 0.1 | 2.1 | 0.9 | 0.07 | 0.17 | 18.9 | 0.1 | 2.9 | 0.84 | 0.01 | 0.15 | 21 | 0.0067 |
| AC-05-SS-1530-100912 | 10/9/2012 | 14 | 0.6 | 2 | 4.62 | 0.1 | 0.55 | 0.63 | 0.07 | 0.13 | 4.05 | 0.07 | 0.65 | 0.63 | 0.02 | 0.12 | 11 | 0.01 |
| AC-05-SS-3045-100912 | 10/9/2012 | 13 | 0.6 | 1.9 | 1.25 | 0.09 | 0.16 | 0.446 | 0.07 | 0.096 | 0.86 | 0.07 | 0.16 | 0.451 | 0.018 | 0.088 | 6.5 | 0.0069 |
| AC-06-SS-0015-101612 | 10/16/2012 | 14.3 | 0.3 | 1.9 | 0.588 | 0.059 | 0.08 | 0.5 | 0.06 | 0.1 | 0.66 | 0.07 | 0.13 | 0.56 | 0.01 | 0.11 | 1.0 | 0.0069 |

## Table 4-13. Soil Sample Results: Radionuclides (continued)

| | | Potassium-40 (pCi g$^{-1}$) | | | Radium-226 (pCi g$^{-1}$) | | | Thorium-228 (pCi g$^{-1}$) | | | Thorium-230 (pCi g$^{-1}$) | | | Thorium-232 (pCi g$^{-1}$) | | | Uranium (pCi g$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL |
| AC-06-SS-15145-101612 | 10/16/2012 | 12.3 | 0.7 | 1.7 | 10.2 | 0.1 | 1.2 | 0.48 | 0.09 | 0.11 | 8.2 | 0.1 | 1.3 | 0.471 | 0.023 | 0.097 | 9 | 0.0069 |
| AC-06-SS-145300-101612 | 10/16/2012 | 11.3 | 0.3 | 1.6 | 0.437 | 0.063 | 0.065 | 0.66 | 0.08 | 0.13 | 0.51 | 0.08 | 0.11 | 0.71 | 0.02 | 0.13 | 2.2 | 0.0069 |
| AC-07-SS-0015-101012 | 10/10/2012 | 15.2 | 1.3 | 2.2 | 39.4 | 0.2 | 4.6 | 0.89 | 0.09 | 0.17 | 45.6 | 0.1 | 7.1 | 0.77 | 0.02 | 0.14 | 29 | 0.0067 |
| AC-07-SS-15105-101012 | 10/10/2012 | 15.4 | 1.3 | 2.2 | 55.1 | 0.2 | 6.5 | 0.92 | 0.07 | 0.17 | 58.2 | 0.1 | 9 | 0.93 | 0.02 | 0.17 | 105 | 0.0069 |
| AC-07-SS-105120-101012 | 10/10/2012 | 15.4 | 0.5 | 2.1 | 1.6 | 0.11 | 0.21 | 0.93 | 0.09 | 0.18 | 5.37 | 0.08 | 0.86 | 0.98 | 0.03 | 0.18 | 5 | 0.0067 |
| AC-08-SS-0015-101012 | 10/10/2012 | 16.2 | 2.4 | 2.6 | 129 | 0 | 15 | 0.96 | 0.09 | 0.18 | 138 | 0 | 22 | 0.92 | 0.04 | 0.17 | 203 | 0.0069 |
| AC-08-SS-1560-101012 | 10/10/2012 | 17.1 | 0.9 | 2.3 | 12.9 | 0.1 | 1.5 | 1.28 | 0.11 | 0.24 | 2.85 | 0.1 | 0.48 | 1.27 | 0.03 | 0.23 | 2.9 | 0.0067 |
| AC-08-SS-6075-101012 | 10/10/2012 | 17.2 | 0.4 | 2.3 | 1.92 | 0.08 | 0.24 | 1.36 | 0.09 | 0.24 | 1.18 | 0.08 | 0.21 | 1.37 | 0.01 | 0.24 | 1 | 0.0069 |
| AC-09-SS-0015-101012 | 10/10/2012 | 18.3 | 0.4 | 2.4 | 2.88 | 0.08 | 0.35 | 1.17 | 0.08 | 0.21 | 2.9 | 0.08 | 0.48 | 1.05 | 0.02 | 0.19 | 5.5 | 0.0067 |
| AC-09-SS-1530-101012 | 10/10/2012 | 17.7 | 0.4 | 2.4 | 1.66 | 0.09 | 0.21 | 0.88 | 0.09 | 0.17 | 0.89 | 0.08 | 0.17 | 0.95 | 0.03 | 0.17 | 1.7 | 0.0067 |
| AC-10-SS-0015-101012 | 10/10/2012 | 15.6 | 2.4 | 2.5 | 113 | 0 | 13 | 0.83 | 0.09 | 0.16 | 141 | 0 | 22 | 0.85 | 0.01 | 0.16 | 175 | 0.0069 |
| AC-10-SS-1590-101012 | 10/10/2012 | 16.4 | 0.9 | 2.2 | 16.8 | 0.2 | 2 | 1 | 0.05 | 0.18 | 20.3 | 0.1 | 3.2 | 0.91 | 0.01 | 0.16 | 60 | 0.0069 |
| AC-10-SS-90105-101012 | 10/10/2012 | 17.4 | 0.4 | 2.3 | 3.32 | 0.09 | 0.4 | 1.28 | 0.07 | 0.22 | 7.2 | 0.1 | 1.1 | 1.29 | 0.02 | 0.22 | 1.6 | 0.0069 |
| AC-11-SS-0015-10112 | 10/10/2012 | 14.7 | 0.5 | 2 | 8.27 | 0.1 | 0.98 | 0.76 | 0.1 | 0.16 | 8.3 | 0.1 | 1.3 | 0.65 | 0.03 | 0.13 | 5.9 | 0.0067 |
| AC-11-SS-1545-101012 | 10/10/2012 | 9.8 | 0.4 | 1.4 | 0.83 | 0.08 | 0.11 | 0.52 | 0.1 | 0.12 | 0.69 | 0.08 | 0.14 | 0.43 | 0.006 | 0.09 | 5.4 | 0.01 |
| AC-11-SS-4560-101012 | 10/10/2012 | 13 | 0.4 | 1.8 | 3.94 | 0.09 | 0.47 | 0.7 | 0.1 | 0.15 | 5.09 | 0.09 | 0.82 | 0.67 | 0.03 | 0.13 | 5.9 | 0.0067 |
| AC-12-SS-0015-100912 | 10/9/2012 | 13.3 | 0.7 | 1.9 | 8 | 0.12 | 0.95 | 0.71 | 0.14 | 0.17 | 5.23 | 0.1 | 0.86 | 0.73 | 0.02 | 0.15 | 3.8 | 0.01 |
| AC-12-SS-1530-100912 | 10/9/2012 | 13.8 | 0.4 | 1.8 | 2.82 | 0.08 | 0.34 | 0.81 | 0.07 | 0.16 | 2.94 | 0.1 | 0.49 | 0.67 | 0.02 | 0.13 | 6 | 0.0068 |
| AC-13-SS-0015-100912 | 10/9/2012 | 15.1 | 1 | 2.1 | 22.7 | 0.2 | 2.7 | 0.91 | 0.16 | 0.21 | 12.9 | 0.1 | 2.1 | 0.9 | 0.04 | 0.18 | 13 | 0.0069 |
| AC-13-SS-1545-100912 | 10/9/2012 | 15.6 | 0.6 | 2.1 | 4.05 | 0.09 | 0.49 | 1.18 | 0.11 | 0.23 | 2.3 | 0.1 | 0.4 | 1.01 | 0.06 | 0.19 | 11 | 0.0069 |
| AC-13-SS-4560-100912 | 10/9/2012 | 13.8 | 0.4 | 1.9 | 1.15 | 0.08 | 0.15 | 0.92 | 0.09 | 0.18 | 1.12 | 0.08 | 0.2 | 0.73 | 0.02 | 0.14 | 3.7 | 0.0069 |
| AC-14-SS-0015-100912 | 10/9/2012 | 18.3 | 0.9 | 2.5 | 12.9 | 0.2 | 1.5 | 1.41 | 0.07 | 0.25 | 20.4 | 0.1 | 3.2 | 1.33 | 0.03 | 0.23 | 26 | 0.01 |
| AC-14-SS-1530-100912 | 10/9/2012 | 17.5 | 0.5 | 2.3 | 2.16 | 0.09 | 0.27 | 1.35 | 0.1 | 0.25 | 1.95 | 0.09 | 0.34 | 1.28 | 0.02 | 0.23 | 12 | 0.00679 |
| AC-14-SS-3045-100912 | 10/9/2012 | 13.5 | 0.3 | 1.8 | 0.88 | 0.06 | 0.11 | 0.72 | 0.08 | 0.15 | 0.62 | 0.08 | 0.13 | 0.65 | 0.04 | 0.13 | 2.3 | 0.00679 |
| AC-15-22-0015-101012 | 10/10/2012 | 16 | 1.3 | 2.3 | 45.7 | 0.2 | 5.4 | 0.77 | 0.07 | 0.15 | 53.1 | 0.1 | 8.2 | 0.76 | 0.02 | 0.14 | 20 | 0.00679 |
| AC-15-22-15105-101012 | 10/10/2012 | 16.1 | 1.4 | 2.3 | 58.1 | 0.3 | 6.8 | 0.96 | 0.11 | 0.19 | 88 | 0 | 14 | 0.92 | 0.04 | 0.17 | 133 | 0.00693 |
| AC-15-22-105120-101012 | 10/10/2012 | 19.2 | 0.6 | 2.5 | 4.84 | 0.12 | 0.58 | 1.37 | 0.11 | 0.26 | 1.07 | 0.1 | 0.21 | 1.26 | 0.03 | 0.23 | 2.2 | 0.00693 |
| AC-16-SS-0015-101612 | 10/16/2012 | 14.4 | 1.8 | 2.3 | 41.6 | 0.3 | 4.9 | 0.83 | 0.13 | 0.18 | 7.6 | 0.1 | 1.2 | 0.92 | 0.03 | 0.18 | 6.7 | 0.00665 |
| AC-16-SS-1555-101612[a] | 10/16/2012 | 14.3 | 0.8 | 2.3 | 0.72 | 0.13 | 0.12 | 1.17 | 0.07 | 0.21 | 0.96 | 0.09 | 0.18 | 1.15 | 0.03 | 0.21 | 1.5 | 0.00693 |

## Table 4-13. Soil Sample Results: Radionuclides (continued)

| | | Potassium-40 (pCi g-1) | | | Radium-226 (pCi g-1) | | | Thorium-228 (pCi g-1) | | | Thorium-230 (pCi g-1) | | | Thorium-232 (pCi g-1) | | | Uranium (pCi g-1) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL |
| AC-16-SS-55125-101612[a] | 10/16/2012 | 16.1 | 1.3 | 2.3 | 24.1 | 0.2 | 2.8 | 1.23 | 0.11 | 0.23 | 1.52 | 0.09 | 0.27 | 1.17 | 0.03 | 0.21 | 3.1 | 0.00693 |
| AC-17-SS-0015-101012 | 10/10/2012 | 17 | 1.8 | 2.6 | 66 | 0.3 | 7.7 | 0.98 | 0.19 | 0.23 | 13.7 | 0.1 | 2.2 | 0.87 | 0.05 | 0.19 | 5.7 | 0.00693 |
| AC-17-SS-15105-101012 | 10/10/2012 | 13.9 | 1.2 | 2 | 35.9 | 0.2 | 4.2 | 0.94 | 0.09 | 0.18 | 8.9 | 0.1 | 1.4 | 0.93 | 0.03 | 0.17 | 6 | 0.0067 |
| AC-17-SS-105120-101012 | 10/10/2012 | 16.6 | 0.6 | 2.3 | 1.68 | 0.11 | 0.21 | 1.27 | 0.13 | 0.25 | 1.04 | 0.1 | 0.21 | 1.17 | 0.02 | 0.22 | 11 | 0.008 |
| AC-18-SS-0015-100912 | 10/9/2012 | 17.4 | 0.5 | 2.3 | 3.21 | 0.1 | 0.39 | 1.21 | 0.16 | 0.25 | 1.61 | 0.11 | 0.3 | 1.09 | 0.01 | 0.21 | 3.3 | 0.01 |
| AC-18-SS-1530-100912 | 10/9/2012 | 16.6 | 0.4 | 2.2 | 1.46 | 0.09 | 0.18 | 1.46 | 0.09 | 0.26 | 1.18 | 0.09 | 0.22 | 1.35 | 0.03 | 0.24 | 3.3 | 0.01 |
| AC-19-SS-0015-101012 | 10/10/2012 | 16.4 | 2.2 | 2.5 | 115 | 0 | 13 | 1.02 | 0.1 | 0.2 | 42.9 | 0.1 | 6.7 | 0.91 | 0.03 | 0.17 | 53 | 0.0068 |
| AC-19-SS-1530-101012 | 10/10/2012 | 14.3 | 0.6 | 2 | 5.42 | 0.12 | 0.65 | 0.67 | 0.09 | 0.14 | 3.15 | 0.09 | 0.52 | 0.61 | 0.03 | 0.12 | 3.8 | 0.0067 |
| AC-19-SS-3045-101012 | 10/10/2012 | 14.6 | 0.3 | 1.9 | 1.65 | 0.07 | 0.2 | 0.86 | 0.11 | 0.18 | 0.88 | 0.09 | 0.17 | 0.91 | 0.03 | 0.17 | 1.3 | 0.0069 |
| AC-20-SS-0015-110912 | 11/9/2012 | 15.2 | 0.7 | 2.1 | 7.49 | 0.15 | 0.89 | 0.8 | 0.1 | 0.16 | 6.5 | 0.1 | 1 | 0.82 | 0.02 | 0.15 | 6.9 | 0.0068 |
| AC-20-SS-1545-110912 | 11/9/2012 | 15.1 | 0.4 | 2 | 2.18 | 0.09 | 0.27 | 0.91 | 0.07 | 0.17 | 2.98 | 0.08 | 0.49 | 0.93 | 0.03 | 0.17 | 4.7 | 0.0067 |
| AC-20-SS-4560-110912 | 11/9/2012 | 15.8 | 0.5 | 2.1 | 1.14 | 0.08 | 0.15 | 1 | 0.1 | 0.19 | 0.95 | 0.1 | 0.18 | 0.95 | 0.03 | 0.18 | 3.3 | 0.0069 |
| AC-21-SS-0015-100912[b] | 10/9/2012 | 16.8 | 1.1 | 2.4 | 9.1 | 0.2 | 1.1 | 1.67 | 0.09 | 0.29 | 4.55 | 0.08 | 0.73 | 1.48 | 0.02 | 0.26 | 21 | 0.0069 |
| AC-21-SS-1545-100912[b] | 10/9/2012 | 13.5 | 0.4 | 1.8 | 1.09 | 0.07 | 0.14 | 0.86 | 0.09 | 0.17 | 0.83 | 0.09 | 0.16 | 0.84 | 0.02 | 0.16 | 4.6 | 0.0067 |
| AC-21-SS-4560-100912[b] | 10/9/2012 | 12.6 | 0.6 | 1.8 | 1.29 | 0.09 | 0.17 | 0.59 | 0.1 | 0.13 | 0.6 | 0.09 | 0.13 | 0.55 | 0.01 | 0.11 | 6 | 0.01 |
| AC-22-SS-0015-100912[c] | 10/9/2012 | 15.2 | 1 | 2.1 | 28.8 | 0.2 | 3.4 | 1.04 | 0.07 | 0.19 | 18.6 | 0.1 | 2.9 | 1.11 | 0.01 | 0.2 | 12 | 0.0069 |
| AC-22-SS-1530-100912[c] | 10/9/2012 | 15.1 | 1.7 | 2.3 | 43.9 | 0.3 | 5.1 | 1.48 | 0.09 | 0.26 | 13.9 | 0.1 | 2.2 | 1.38 | 0.02 | 0.24 | 15 | 0.0067 |
| AC-23-SS-0015-100912 | 10/9/2012 | 17.2 | 1.2 | 2.4 | 30.8 | 0.2 | 3.6 | 1.26 | 0.1 | 0.23 | 1.85 | 0.09 | 0.32 | 1.2 | 0.02 | 0.21 | 5.1 | 0.01 |
| AC-23-SS-1530-100912 | 10/9/2012 | 17.1 | 0.7 | 2.3 | 8.22 | 0.12 | 0.97 | 1.35 | 0.11 | 0.25 | 1.7 | 0.1 | 0.3 | 1.17 | 0.03 | 0.21 | 3.8 | 0.0069 |
| AC-24-SS-1560-101012[d] | 10/10/2012 | 15.9 | 0.4 | 2.1 | 1.85 | 0.08 | 0.23 | 1.06 | 0.18 | 0.24 | 1.12 | 0.12 | 0.23 | 1.14 | 0.05 | 0.23 | 5.8 | 0.0067 |
| AC-25-SS-15105-101012[d] | 10/10/2012 | 16.4 | 1.1 | 2.2 | 45.7 | 0.2 | 5.3 | 0.97 | 0.11 | 0.19 | 30.1 | 0.1 | 4.7 | 0.96 | 0.01 | 0.18 | 46 | 0.0069 |
| AC-26-SS-15105-101012[d] | 10/10/2012 | 14.6 | 1.4 | 2.2 | 38.2 | 0.2 | 4.5 | 0.98 | 0.09 | 0.19 | 10 | 0.1 | 1.6 | 0.8 | 0.03 | 0.15 | 6.4 | 0.0068 |
| AC-27-SS-1545-101012[d] | 10/10/2012 | 13 | 0.5 | 1.8 | 3.79 | 0.09 | 0.46 | 0.76 | 0.08 | 0.15 | 2.68 | 0.08 | 0.44 | 0.72 | 0.02 | 0.14 | 8 | 0.0069 |
| AC-28-SS-1545-101012[d] | 10/10/2012 | 14.6 | 1.3 | 2.1 | 42.2 | 0.2 | 4.9 | 1.05 | 0.08 | 0.19 | 51.2 | 0.1 | 8 | 1.02 | 0.04 | 0.19 | 68 | 0.0068 |
| BRA-01-SS-0015-100812 | 10/8/2012 | 16 | 0.4 | 2.1 | 0.94 | 0.07 | 0.12 | 0.99 | 0.12 | 0.2 | 1.04 | 0.11 | 0.21 | 0.91 | 0.06 | 0.18 | 1.3 | 0.0069 |
| BRA-01-SS-1530-100812 | 10/8/2012 | 14.7 | 0.4 | 2 | 0.686 | 0.067 | 0.095 | 0.85 | 0.1 | 0.17 | 0.87 | 0.09 | 0.17 | 0.94 | 0.02 | 0.17 | 1.1 | 0.0067 |
| BRA-02-SS-0015-100812 | 10/8/2012 | 16.2 | 0.4 | 2.2 | 0.77 | 0.06 | 0.1 | 0.84 | 0.1 | 0.17 | 0.88 | 0.08 | 0.17 | 0.85 | 0.01 | 0.16 | 1.3 | 0.0069 |
| BRA-02-SS-1530-100812 | 10/8/2012 | 13.9 | 0.4 | 1.9 | 0.617 | 0.073 | 0.088 | 0.75 | 0.11 | 0.16 | 0.59 | 0.09 | 0.13 | 0.77 | 0.01 | 0.15 | 1.0 | 0.0067 |
| BRA-03-SS-0015-100812 | 10/8/2012 | 17.3 | 0.4 | 2.3 | 1.23 | 0.08 | 0.16 | 1.45 | 0.11 | 0.26 | 1.6 | 0.09 | 0.28 | 1.39 | 0.03 | 0.25 | 1.8 | 0.0068 |

## Table 4-13. Soil Sample Results: Radionuclides (continued)

| | | Potassium-40 (pCi $g^{-1}$) | | | Radium-226 (pCi $g^{-1}$) | | | Thorium-228 (pCi $g^{-1}$) | | | Thorium-230 (pCi $g^{-1}$) | | | Thorium-232 (pCi $g^{-1}$) | | | Uranium (pCi $g^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL | TPU | Result | PRL |
| BRA-03-SS-1530-100812 | 10/8/2012 | 16 | 0.5 | 2.2 | 1.22 | 0.09 | 0.16 | 1.74 | 0.08 | 0.32 | 1.24 | 0.11 | 0.24 | 1.54 | 0.02 | 0.28 | 1.8 | 0.0068 |
| BRA-04-SS-0015-100812 | 10/8/2012 | 16 | 0.7 | 2.2 | 0.88 | 0.08 | 0.12 | 1.08 | 0.1 | 0.2 | 0.91 | 0.09 | 0.17 | 1.01 | 0.03 | 0.18 | 1.3 | 0.0069 |
| BRA-04-SS-1530-100812 | 10/8/2012 | 15.9 | 0.3 | 2.1 | 0.87 | 0.06 | 0.11 | 1.09 | 0.1 | 0.2 | 0.97 | 0.09 | 0.18 | 1.06 | 0.03 | 0.19 | 1.3 | 0.0068 |
| BRA-05-SS-0015-100812 | 10/8/2012 | 17 | 0.4 | 2.3 | 0.97 | 0.08 | 0.13 | 1.2 | 0.09 | 0.22 | 1.01 | 0.09 | 0.19 | 1.1 | 0.02 | 0.2 | 1.5 | 0.0069 |
| BRA-05-SS-1530-100812 | 10/8/2012 | 14.8 | 0.4 | 2 | 0.79 | 0.06 | 0.1 | 1.02 | 0.09 | 0.2 | 0.8 | 0.09 | 0.16 | 0.98 | 0.02 | 0.18 | 1.3 | 0.0067 |
| BRA-06-SS-0015-100812 | 10/8/2012 | 17.4 | 0.4 | 2.3 | 1.09 | 0.09 | 0.14 | 1.31 | 0.14 | 0.27 | 1.34 | 0.12 | 0.27 | 1.28 | 0.06 | 0.25 | 1.6 | 0.0069 |
| BRA-06-SS-1530-100812 | 10/8/2012 | 15.5 | 0.4 | 2 | 0.89 | 0.07 | 0.12 | 1.11 | 0.11 | 0.21 | 0.94 | 0.1 | 0.18 | 1.02 | 0.05 | 0.19 | 1.3 | 0.0067 |
| BRA-07-SS-0015-100812 | 10/8/2012 | 15.3 | 0.5 | 2.1 | 0.92 | 0.08 | 0.12 | 0.98 | 0.1 | 0.19 | 0.91 | 0.09 | 0.18 | 0.88 | 0.02 | 0.16 | 1 | 0.0069 |
| BRA-07-SS-1530-100812 | 10/8/2012 | 16.4 | 0.4 | 2.2 | 0.92 | 0.08 | 0.12 | 1.44 | 0.24 | 0.33 | 0.95 | 0.14 | 0.23 | 1.45 | 0.02 | 0.3 | 1.8 | 0.0069 |
| BRA-08-SS-0015-100812 | 10/8/2012 | 15.2 | 0.5 | 2.1 | 0.91 | 0.08 | 0.12 | 1 | 0.09 | 0.19 | 0.81 | 0.09 | 0.16 | 1 | 0.03 | 0.18 | 1.5 | 0.0067 |
| BRA-08-SS-1530-100812 | 10/8/2012 | 16.3 | 0.4 | 2.2 | 0.97 | 0.07 | 0.13 | 1.15 | 0.09 | 0.21 | 0.86 | 0.09 | 0.17 | 1.06 | 0.02 | 0.19 | 1.5 | 0.0067 |
| BRA-09-SS-0015-100812 | 10/8/2012 | 16.2 | 0.4 | 2.1 | 1.1 | 0.08 | 0.14 | 1.23 | 0.1 | 0.23 | 1.08 | 0.09 | 0.21 | 1.18 | 0.04 | 0.21 | 1.6 | 0.0069 |
| BRA-09-SS-1530-100812 | 10/8/2012 | 17.5 | 0.4 | 2.4 | 1.05 | 0.08 | 0.14 | 1.38 | 0.12 | 0.26 | 1.07 | 0.1 | 0.21 | 1.37 | 0.05 | 0.25 | 1.3 | 0.0069 |
| BRA-10-SS-0015-100812 | 10/8/2012 | 16.5 | 0.4 | 2.2 | 0.87 | 0.07 | 0.12 | 1 | 0.09 | 0.19 | 1.06 | 0.08 | 0.2 | 1.05 | 0.03 | 0.19 | 1 | 0.0069 |
| BRA-10-SS-1530-100812 | 10/8/2012 | 16.8 | 0.4 | 2.2 | 0.85 | 0.08 | 0.11 | 1.07 | 0.09 | 0.2 | 0.91 | 0.09 | 0.18 | 0.97 | 0.04 | 0.18 | 1.2 | 0.0068 |
| BRA-11-SS-0015-100812 | 10/8/2012 | 14.9 | 0.3 | 2 | 0.78 | 0.06 | 0.1 | 0.86 | 0.09 | 0.16 | 0.76 | 0.08 | 0.15 | 0.92 | 0.02 | 0.16 | 1.1 | 0.0069 |
| BRA-11-SS-1530-100812 | 10/8/2012 | 14.9 | 0.4 | 2 | 0.691 | 0.074 | 0.095 | 0.87 | 0.08 | 0.17 | 0.78 | 0.09 | 0.15 | 0.79 | 0.02 | 0.15 | 1.2 | 0.0069 |
| BRA-12-SS-0015-100812 | 10/8/2012 | 15.1 | 0.3 | 2 | 0.686 | 0.073 | 0.095 | 0.89 | 0.08 | 0.17 | 0.7 | 0.08 | 0.14 | 0.85 | 0.02 | 0.16 | 1.1 | 0.0069 |
| BRA-12-SS-1530-100812 | 10/8/2012 | 15.1 | 0.3 | 2 | 0.75 | 0.06 | 0.1 | 0.97 | 0.09 | 0.19 | 0.83 | 0.09 | 0.16 | 0.98 | 0.03 | 0.18 | 1.3 | 0.0068 |
| BRA-13-SS-0015-100812 | 10/8/2012 | 14.8 | 0.4 | 2 | 0.9 | 0.08 | 0.12 | 1.01 | 0.09 | 0.19 | 1 | 0.09 | 0.19 | 0.91 | 0.02 | 0.17 | 1 | 0.0069 |
| BRA-13-SS-1530-100812 | 10/8/2012 | 16.2 | 0.4 | 2.2 | 0.92 | 0.08 | 0.12 | 1.1 | 0.08 | 0.21 | 0.94 | 0.09 | 0.18 | 1.1 | 0.03 | 0.2 | 1 | 0.0069 |
| BRA-14-SS-0015-100812 | 10/8/2012 | 15.2 | 0.4 | 2 | 0.86 | 0.08 | 0.12 | 0.95 | 0.07 | 0.18 | 0.9 | 0.1 | 0.18 | 0.94 | 0.02 | 0.18 | 1.3 | 0.0069 |
| BRA-14-SS-1530-100812 | 10/8/2012 | 16.1 | 0.4 | 2.1 | 0.89 | 0.08 | 0.12 | 1.1 | 0.09 | 0.2 | 1.02 | 0.09 | 0.19 | 1.08 | 0.03 | 0.19 | 1.5 | 0.0068 |
| BRA-15-SS-0015-100812 | 10/8/2012 | 14 | 0.3 | 1.9 | 0.82 | 0.06 | 0.11 | 0.81 | 0.1 | 0.16 | 0.75 | 0.09 | 0.15 | 0.88 | 0.03 | 0.16 | 1.2 | 0.0068 |
| BRA-15-SS-1530-100812 | 10/8/2012 | 14.9 | 0.4 | 2 | 0.71 | 0.074 | 0.097 | 0.89 | 0.08 | 0.17 | 0.66 | 0.08 | 0.13 | 0.78 | 0.02 | 0.15 | 1.1 | 0.0068 |
| BRA-16-SS-0015-100812[d] | 10/8/2012 | 14.7 | 0.4 | 2 | 0.712 | 0.068 | 0.097 | 0.86 | 0.08 | 0.17 | 0.7 | 0.08 | 0.14 | 0.84 | 0.02 | 0.15 | 1.2 | 0.0069 |
| BRA-16-SS-1530-100812[d] | 10/8/2012 | 14.6 | 0.3 | 2 | 0.707 | 0.072 | 0.098 | 1.04 | 0.2 | 0.25 | 0.59 | 0.14 | 0.17 | 0.69 | 0.08 | 0.17 | 1.1 | 0.0069 |

## Table 4-13. Soil Sample Results: Radionuclides (concluded)

Notes:

[a]The correct identifier for sample AC-16-SS-1555-101512 is AC-16-SS-55125-101612. [a]The correct identifiers for sample AC-16-SS-55125-101512 is AC-16-SS-1555-101612.
[b]The correct identifiers for samples AC-21-SS-0015-100912, AC-21-SS-1545-100912, and AC-21-SS-4560-100912 are AC-22-SS-0015-100912, AC-22-SS-1545-100912, and AC-22-SS-4560-100912, respectively.
[c]The correct identifiers for sample AC-22-SS-0015-100912 and AC-22-SS-1530-100912 are AC-21-SS-0015-100912 and AC-21-SS-1530-100912, respectively.
[d]Sample duplicate

pCi $g^{-1}$ = picocuries per gram
PRL = practical reporting limit
TPU = total propagated uncertainty
U = not detected

# Table 4-14. Soil Sample Results: Indicator Metals

| | | Arsenic (mg kg$^{-1}$) | | Barium (mg kg$^{-1}$) | | Lead (mg kg$^{-1}$) | | Molybdenum (mg kg$^{-1}$) | | Selenium (mg kg$^{-1}$) | | Vanadium (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL |
| AA-01-0015-101512 | 10/15/2012 | 10 | 0.21 | 540 | 0.1 | 21 | 0.052 | 13 | 0.1 | 40 | 0.1 | 290 | 0.1 |
| AA-01-15115-10152 | 10/15/2012 | 4.6 | 0.22 | 460 | 0.11 | 13 | 0.055 | 0.97 | 0.11 | 1.5 | 0.11 | 52 | 0.11 |
| AA-01-115145-101512 | 10/15/2012 | 3.3 | 0.2 | 400 | 0.1 | 9.9 | 0.05 | 2.4 | 0.1 | 0.26 | 0.1 | 11 | 0.1 |
| AA-02-SS-0015-101112 | 10/11/2012 | 10 | 0.2 | 380 | 0.1 | 16 | 0.05 | 0.88 | 0.1 | 0.65 | 0.1 | 60 | 0.1 |
| AA-02-SS-1530-101112 | 10/11/2012 | 13 | 0.2 | 390 | 0.098 | 18 | 0.049 | 0.93 | 0.098 | 0.84 | 0.098 | 64 | 0.098 |
| AA-03-SS-0015-101512 | 10/15/2012 | 6.7 | 0.21 | 450 | 0.1 | 14 | 0.052 | 6.8 | 0.1 | 28 | 0.1 | 190 | 0.1 |
| AA-03-SS-15145-101512 | 10/15/2012 | 20 | 0.21 | 620 | 0.11 | 21 | 0.054 | 36 | 0.11 | 57 | 0.11 | 240 | 0.11 |
| AA-03-SS-145235-101512 | 10/15/2012 | 6.5 | 0.22 | 500 | 0.11 | 13 | 0.054 | 1 | 0.11 | 1 | 0.11 | 37 | 0.11 |
| AA-04-SS-0015-102212 | 10/22/2012 | 12 | 0.21 | 360 | 0.1 | 17 | 0.052 | 56 | 0.1 | 20 | 0.1 | 120 | 0.1 |
| AA-04-SS-15205-102212 | 10/22/2012 | 1.9 | 0.22 | 450 | 0.11 | 15 | 0.055 | 1.2 | 0.11 | 1.6 | 0.11 | 47 | 0.11 |
| AA-04-SS-205300-102212 | 10/22/2012 | 10 | 0.23 | 350 | 0.12 | 21 | 0.058 | 1.2 | 0.12 | 0.89 | 0.12 | 64 | 0.12 |
| AA-05-SS-0015-102212 | 10/22/2012 | 3.7 | 0.19 | 430 | 0.097 | 11 | 0.049 | 1.1 | 0.097 | 1.1 | 0.097 | 29 | 0.097 |
| AA-05-SS-15230-101612 | 10/16/2012 | 2.3 | 0.19 | 360 | 0.097 | 7.5 | 0.049 | 0.8 | 0.097 | 0.2 | 0.097 | 14 | 0.097 |
| AA-06-SS-0015-101612 | 10/16/2012 | 5 | 0.21 | 790 | 0.11 | 14 | 0.053 | 4.2 | 0.11 | 10 | 0.11 | 110 | 0.11 |
| AA-06-SS-15355-101612 | 10/16/2012 | 3.8 | 0.2 | 410 | 0.1 | 13 | 0.051 | 5 | 0.1 | 3.2 | 0.1 | 36 | 0.1 |
| AA-07-SS-0015-101612 | 10/16/2012 | 7.4 | 0.21 | 540 | 0.11 | 16 | 0.053 | 7.7 | 0.11 | 21 | 0.11 | 120 | 0.11 |
| AA-07-SS-15415-101612 | 10/16/2012 | 10 | 0.25 | 600 | 0.12 | 20 | 0.061 | 14 | 0.12 | 39 | 0.12 | 190 | 0.12 |
| AA-07-SS-415505-101612 | 10/16/2012 | 9.4 | 0.25 | 530 | 0.13 | 16 | 0.063 | 2.3 | 0.13 | 0.93 | 0.13 | 61 | 0.13 |
| AA-08-SS-0015-101612 | 10/16/2012 | 7 | 0.2 | 500 | 0.1 | 15 | 0.05 | 3 | 0.1 | 15 | 0.1 | 140 | 0.1 |
| AA-08-SS-15565-101612 | 10/16/2012 | 5.4 | 0.21 | 480 | 0.1 | 14 | 0.052 | 7.3 | 0.1 | 16 | 0.1 | 130 | 0.1 |
| AA-08-SS-565795-101612 | 10/16/2012 | 15 | 0.22 | 170 | 0.11 | 23 | 0.056 | 1.8 | 0.11 | 0.59 | 0.11 | 82 | 0.11 |
| AA-09-SS-0015-101612 | 10/16/2012 | 8.6 | 0.21 | 540 | 0.11 | 18 | 0.053 | 6.6 | 0.11 | 67 | 0.11 | 230 | 0.11 |
| AA-09-SS-15750-101612 | 10/16/2012 | 9 | 0.21 | 490 | 0.11 | 19 | 0.053 | 13 | 0.11 | 43 | 0.11 | 270 | 0.11 |
| AA-09-SS-750950-101612 | 10/16/2012 | 12 | 0.25 | 560 | 0.12 | 21 | 0.061 | 2.4 | 0.12 | 0.77 | 0.12 | 88 | 0.12 |
| AA-10-SS-0015-101512 | 10/15/2012 | 9.1 | 0.2 | 410 | 0.099 | 19 | 0.05 | 15 | 0.099 | 68 | 0.099 | 150 | 0.099 |
| AA-10-SS-15415-101512 | 10/15/2012 | 7.6 | 0.22 | 230 | 0.11 | 13 | 0.056 | 2.4 | 0.11 | 4.1 | 0.11 | 37 | 0.11 |
| AA-10-SS-415525-101512 | 10/15/2012 | 5.4 | 0.22 | 440 | 0.11 | 16 | 0.056 | 1.3 | 0.11 | 0.6 | 0.11 | 45 | 0.11 |
| AA-11-SS-0015-101512 | 10/15/2012 | 6 | 0.19 | 240 | 0.095 | 13 | 0.048 | 5.3 | 0.095 | 5.1 | 0.095 | 69 | 0.095 |
| AA-11-SS-15145-101512 | 10/15/2012 | 7.1 | 0.2 | 360 | 0.098 | 14 | 0.049 | 4.4 | 0.098 | 8.5 | 0.098 | 95 | 0.098 |

## Table 4-14. Soil Sample Results: Indicator Metals (continued)

| Sample ID | Date Collected | Arsenic (mg kg$^{-1}$) | | Barium (mg kg$^{-1}$) | | Lead (mg kg$^{-1}$) | | Molybdenum (mg kg$^{-1}$) | | Selenium (mg kg$^{-1}$) | | Vanadium (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL |
| AA-11-SS-145245-101512 | 10/15/2012 | 4 | 0.2 | 420 | 0.099 | 11 | 0.049 | 0.68 | 0.099 | 0.81 | 0.099 | 30 | 0.099 |
| AA-12-SS-0015-101512 | 10/15/2012 | 12 | 0.23 | 560 | 0.12 | 21 | 0.058 | 16 | 0.12 | 33 | 0.12 | 240 | 0.12 |
| AA-12-SS-15115-101512 | 10/15/2012 | 16 | 0.22 | 390 | 0.11 | 22 | 0.054 | 6.2 | 0.11 | 13 | 0.11 | 100 | 0.11 |
| AA-12-SS-115245-101512 | 10/15/2012 | 5 | 0.2 | 460 | 0.099 | 12 | 0.05 | 1.7 | 0.099 | 5.1 | 0.099 | 43 | 0.099 |
| AB-01-SS-0015-101112 | 10/11/2012 | 3.2 | 0.19 | 410 | 0.097 | 10 | 0.049 | 2 | 0.097 | 0.57 | 0.097 | 20 | 0.097 |
| AB-01-SS-1530-101112 | 10/11/2012 | 2.9 | 0.2 | 360 | 0.098 | 9.3 | 0.049 | 2 | 0.098 | 0.33 | 0.098 | 19 | 0.098 |
| AB-02-SS-0015-101112 | 10/11/2012 | 3.5 | 0.2 | 500 | 0.1 | 12 | 0.05 | 0.9 | 0.1 | 1.1 | 0.1 | 22 | 0.1 |
| AB-02-SS-1530-101112 | 10/11/2012 | 2.5 | 0.19 | 500 | 0.097 | 10 | 0.049 | 0.64 | 0.097 | 0.39 | 0.097 | 17 | 0.097 |
| AB-03-SS-0015-101112 | 10/11/2012 | 3.2 | 0.2 | 370 | 0.099 | 9.4 | 0.049 | 0.81 | 0.099 | 0.33 | 0.099 | 22 | 0.099 |
| AB-03-SS-1530-101112 | 10/11/2012 | 4.2 | 0.19 | 390 | 0.096 | 11 | 0.048 | 1.3 | 0.096 | 0.43 | 0.096 | 29 | 0.096 |
| AB-04-SS-0015-101112 | 10/11/2012 | 6.1 | 0.19 | 400 | 0.097 | 13 | 0.048 | 0.94 | 0.097 | 0.49 | 0.097 | 44 | 0.097 |
| AB-04-SS-1530-101112 | 10/11/2012 | 5.9 | 0.2 | 410 | 0.1 | 13 | 0.05 | 0.85 | 0.1 | 0.47 | 0.1 | 42 | 0.1 |
| AB-05-SS-0015-101112 | 10/11/2012 | 4.2 | 0.2 | 410 | 0.099 | 12 | 0.049 | 0.71 | 0.099 | 0.46 | 0.099 | 30 | 0.099 |
| AB-05-SS-1530-101112 | 10/11/2012 | 4.5 | 0.2 | 420 | 0.099 | 12 | 0.049 | 0.73 | 0.099 | 0.54 | 0.099 | 30 | 0.099 |
| AC-01-SS-0015-100912 | 10/9/2012 | 8.9 | 0.19 | 400 | 0.096 | 16 | 0.048 | 1.6 | 0.096 | 1.3 | 0.096 | 56 | 0.096 |
| AC-01-SS-1530-100912 | 10/9/2012 | 8.9 | 0.2 | 290 | 0.1 | 16 | 0.05 | 2.2 | 0.1 | 1.2 | 0.1 | 58 | 0.1 |
| AC-01-SS-3045-100912 | 10/9/2012 | 7 | 0.2 | 360 | 0.098 | 14 | 0.049 | 2.4 | 0.098 | 0.81 | 0.098 | 40 | 0.098 |
| AC-02-SS-0015-100912 | 10/10/2012 | 7.3 | 0.2 | 440 | 0.1 | 14 | 0.05 | 1.5 | 0.1 | 1.7 | 0.1 | 49 | 0.1 |
| AC-02-SS-1560-100912 | 10/10/2012 | 7.2 | 0.19 | 390 | 0.097 | 14 | 0.048 | 2.2 | 0.097 | 1 | 0.097 | 43 | 0.097 |
| AC-02-SS-6075-100912 | 10/10/2012 | 8.2 | 0.2 | 410 | 0.098 | 15 | 0.049 | 3.2 | 0.098 | 1.3 | 0.098 | 41 | 0.098 |
| AC-03-SS-0015-100912 | 10/9/2012 | 5.8 | 0.19 | 370 | 0.097 | 14 | 0.048 | 1.6 | 0.097 | 3.6 | 0.097 | 52 | 0.097 |
| AC-03-SS-1530-100912 | 10/9/2012 | 6.2 | 0.19 | 320 | 0.096 | 14 | 0.048 | 0.99 | 0.096 | 0.54 | 0.096 | 48 | 0.096 |
| AC-04-SS-0015-100912 | 10/19/2012 | 4.4 | 0.2 | 370 | 0.098 | 11 | 0.049 | 1.1 | 0.098 | 1.2 | 0.098 | 34 | 0.098 |
| AC-04-SS-1530-100912 | 10/19/2012 | 3.8 | 0.2 | 390 | 0.098 | 10 | 0.049 | 1.1 | 0.098 | 0.68 | 0.098 | 24 | 0.098 |
| AC-04-SS-3045-100912 | 10/19/2012 | 3.8 | 0.2 | 390 | 0.099 | 11 | 0.049 | 1.3 | 0.099 | 0.58 | 0.099 | 24 | 0.099 |
| AC-05-SS-0015-100912 | 10/9/2012 | 8.6 | 0.19 | 400 | 0.096 | 18 | 0.048 | 3.3 | 0.096 | 11 | 0.096 | 110 | 0.096 |
| AC-05-SS-1530-100912 | 10/9/2012 | 5.3 | 0.2 | 450 | 0.1 | 13 | 0.05 | 2.3 | 0.1 | 1.5 | 0.1 | 40 | 0.1 |
| AC-05-SS-3045-100912 | 10/9/2012 | 3 | 0.2 | 380 | 0.099 | 8.9 | 0.049 | 1.2 | 0.099 | 0.53 | 0.099 | 18 | 0.099 |
| AC-06-SS-0015-101612 | 10/16/2012 | 3.4 | 0.2 | 400 | 0.099 | 10 | 0.049 | 0.95 | 0.099 | 0.58 | 0.099 | 21 | 0.099 |

## Table 4-14. Soil Sample Results: Indicator Metals (continued)

| | | Arsenic (mg kg$^{-1}$) | | Barium (mg kg$^{-1}$) | | Lead (mg kg$^{-1}$) | | Molybdenum (mg kg$^{-1}$) | | Selenium (mg kg$^{-1}$) | | Vanadium (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL |
| AC-06-SS-15145-101612 | 10/16/2012 | 3.5 | 0.2 | 410 | 0.099 | 9.8 | 0.049 | 1.7 | 0.099 | 1.9 | 0.099 | 34 | 0.099 |
| AC-06-SS-145300-101612 | 10/16/2012 | 4.6 | 0.2 | 410 | 0.098 | 11 | 0.049 | 0.61 | 0.098 | 0.53 | 0.098 | 36 | 0.098 |
| AC-07-SS-0015-101012 | 10/10/2012 | 6.4 | 0.19 | 430 | 0.096 | 14 | 0.048 | 2.7 | 0.096 | 6.4 | 0.096 | 70 | 0.096 |
| AC-07-SS-15105-101012 | 10/10/2012 | 6.8 | 0.2 | 410 | 0.099 | 15 | 0.049 | 8.2 | 0.099 | 6.3 | 0.099 | 87 | 0.099 |
| AC-07-SS-105120-101012 | 10/10/2012 | 7.6 | 0.19 | 360 | 0.095 | 14 | 0.048 | 0.94 | 0.095 | 0.86 | 0.095 | 51 | 0.095 |
| AC-08-SS-0015-101012 | 10/10/2012 | 5.9 | 0.2 | 330 | 0.098 | 13 | 0.049 | 13 | 0.098 | 12 | 0.098 | 89 | 0.098 |
| AC-08-SS-1560-101012 | 10/10/2012 | 7.3 | 0.19 | 290 | 0.096 | 17 | 0.048 | 1.3 | 0.096 | 1.3 | 0.096 | 67 | 0.096 |
| AC-08-SS-6075-101012 | 10/10/2012 | 6.8 | 0.2 | 300 | 0.099 | 16 | 0.05 | 0.78 | 0.099 | 0.58 | 0.099 | 62 | 0.099 |
| AC-09-SS-0015-101012 | 10/10/2012 | 8.5 | 0.19 | 370 | 0.096 | 17 | 0.048 | 1.5 | 0.096 | 0.58 | 0.096 | 62 | 0.096 |
| AC-09-SS-1530-101012 | 10/10/2012 | 6.2 | 0.19 | 360 | 0.095 | 14 | 0.048 | 0.61 | 0.095 | 0.47 | 0.095 | 45 | 0.095 |
| AC-10-SS-0015-101012 | 10/10/2012 | 8.8 | 0.2 | 460 | 0.098 | 19 | 0.049 | 4.8 | 0.098 | 27 | 0.098 | 190 | 0.098 |
| AC-10-SS-1590-101012 | 10/10/2012 | 7.4 | 0.2 | 400 | 0.099 | 16 | 0.049 | 2.2 | 0.099 | 5.5 | 0.099 | 69 | 0.099 |
| AC-10-SS-90105-101012 | 10/10/2012 | 7.4 | 0.2 | 300 | 0.098 | 15 | 0.049 | 0.76 | 0.098 | 0.68 | 0.098 | 56 | 0.098 |
| AC-11-SS-0015-10112 | 10/10/2012 | 4.2 | 0.19 | 420 | 0.096 | 11 | 0.048 | 1.4 | 0.096 | 2.5 | 0.096 | 37 | 0.096 |
| AC-11-SS-1545-101012 | 10/10/2012 | 5.1 | 0.2 | 320 | 0.1 | 8.2 | 0.051 | 2.5 | 0.1 | 0.47 | 0.1 | 20 | 0.1 |
| AC-11-SS-4560-101012 | 10/10/2012 | 4 | 0.19 | 390 | 0.096 | 10 | 0.048 | 1.9 | 0.096 | 1.4 | 0.096 | 31 | 0.096 |
| AC-12-SS-0015-100912 | 10/9/2012 | 4.3 | 0.2 | 430 | 0.1 | 11 | 0.05 | 1.2 | 0.1 | 1.4 | 0.1 | 33 | 0.1 |
| AC-12-SS-1530-100912 | 10/9/2012 | 5.2 | 0.19 | 470 | 0.097 | 13 | 0.049 | 1.8 | 0.097 | 0.66 | 0.097 | 39 | 0.097 |
| AC-13-SS-0015-100912 | 10/9/2012 | 7.6 | 0.2 | 430 | 0.098 | 16 | 0.049 | 2.2 | 0.098 | 3.8 | 0.098 | 73 | 0.098 |
| AC-13-SS-1545-100912 | 10/9/2012 | 5.7 | 0.2 | 420 | 0.098 | 14 | 0.049 | 2.6 | 0.098 | 0.97 | 0.098 | 45 | 0.098 |
| AC-13-SS-4560-100912 | 10/9/2012 | 4.5 | 0.2 | 420 | 0.098 | 11 | 0.049 | 1.6 | 0.098 | 0.74 | 0.098 | 32 | 0.098 |
| AC-14-SS-0015-100912 | 10/9/2012 | 8.1 | 0.2 | 440 | 0.1 | 17 | 0.05 | 3 | 0.1 | 6.8 | 0.1 | 91 | 0.1 |
| AC-14-SS-1530-100912 | 10/9/2012 | 7.3 | 0.19 | 410 | 0.097 | 16 | 0.049 | 2.1 | 0.097 | 1.2 | 0.097 | 62 | 0.097 |
| AC-14-SS-3045-100912 | 10/9/2012 | 4 | 0.19 | 410 | 0.097 | 11 | 0.049 | 0.9 | 0.097 | 0.47 | 0.097 | 27 | 0.097 |
| AC-15-22-0015-101012 | 10/10/2012 | 6.1 | 0.19 | 490 | 0.097 | 13 | 0.048 | 1.6 | 0.097 | 7.1 | 0.097 | 79 | 0.097 |
| AC-15-22-15105-101012 | 10/10/2012 | 7.4 | 0.2 | 420 | 0.099 | 20 | 0.049 | 5.6 | 0.099 | 4.8 | 0.099 | 86 | 0.099 |
| AC-15-22-105120-101012 | 10/10/2012 | 5.9 | 0.2 | 410 | 0.099 | 15 | 0.05 | 0.82 | 0.099 | 0.81 | 0.099 | 47 | 0.099 |
| AC-16-SS-0015-101612 | 10/16/2012 | 8.2 | 0.19 | 460 | 0.095 | 13 | 0.048 | 2.8 | 0.095 | 1.8 | 0.095 | 47 | 0.095 |
| AC-16-SS-1555-101612[a] | 10/16/2012 | 6.2 | 0.2 | 400 | 0.099 | 15 | 0.05 | 0.61 | 0.099 | 0.86 | 0.099 | 49 | 0.099 |

## Table 4-14. Soil Sample Results: Indicator Metals (continued)

| | | Arsenic (mg kg$^{-1}$) | | Barium (mg kg$^{-1}$) | | Lead (mg kg$^{-1}$) | | Molybdenum (mg kg$^{-1}$) | | Selenium (mg kg$^{-1}$) | | Vanadium (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Date Collected | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL | Result | PRL |
| AC-16-SS-55125-101612[a] | 10/16/2012 | 6.1 | 0.2 | 360 | 0.099 | 13 | 0.049 | 1.2 | 0.099 | 0.77 | 0.099 | 40 | 0.099 |
| AC-17-SS-0015-101012 | 10/10/2012 | 6.6 | 0.2 | 440 | 0.099 | 15 | 0.05 | 1.3 | 0.099 | 1.9 | 0.099 | 63 | 0.099 |
| AC-17-SS-15105-101012 | 10/10/2012 | 6.4 | 0.19 | 450 | 0.096 | 12 | 0.048 | 1.5 | 0.096 | 0.85 | 0.096 | 45 | 0.096 |
| AC-17-SS-105120-101012 | 10/10/2012 | 8.6 | 0.21 | 450 | 0.11 | 15 | 0.053 | 1.9 | 0.11 | 0.74 | 0.11 | 52 | 0.11 |
| AC-18-SS-0015-100912 | 10/9/2012 | 8.5 | 0.2 | 400 | 0.1 | 15 | 0.05 | 1.3 | 0.1 | 0.78 | 0.1 | 52 | 0.1 |
| AC-18-SS-1530-100912 | 10/9/2012 | 8.6 | 0.2 | 340 | 0.1 | 15 | 0.05 | 1.4 | 0.1 | 0.74 | 0.1 | 54 | 0.1 |
| AC-19-SS-0015-101012 | 10/10/2012 | 9.3 | 0.19 | 560 | 0.097 | 15 | 0.049 | 5.2 | 0.097 | 4.3 | 0.097 | 100 | 0.097 |
| AC-19-SS-1530-101012 | 10/10/2012 | 4.3 | 0.19 | 440 | 0.096 | 11 | 0.048 | 1.5 | 0.096 | 1.3 | 0.096 | 29 | 0.096 |
| AC-19-SS-3045-101012 | 10/10/2012 | 5.2 | 0.2 | 450 | 0.098 | 11 | 0.049 | 0.81 | 0.098 | 0.61 | 0.098 | 31 | 0.098 |
| AC-20-SS-0015-110912 | 11/9/2012 | 5.6 | 0.19 | 400 | 0.097 | 13 | 0.048 | 1.5 | 0.097 | 1.9 | 0.097 | 52 | 0.097 |
| AC-20-SS-1545-110912 | 11/9/2012 | 6.2 | 0.19 | 380 | 0.096 | 14 | 0.048 | 2 | 0.096 | 0.68 | 0.096 | 50 | 0.096 |
| AC-20-SS-4560-110912 | 11/9/2012 | 6 | 0.2 | 440 | 0.098 | 14 | 0.049 | 2 | 0.098 | 0.61 | 0.098 | 48 | 0.098 |
| AC-21-SS-0015-100912[b] | 10/9/2012 | 9.2 | 0.2 | 370 | 0.099 | 18 | 0.049 | 14 | 0.099 | 4.2 | 0.099 | 77 | 0.099 |
| AC-21-SS-1545-100912[b] | 10/9/2012 | 5.2 | 0.19 | 470 | 0.096 | 11 | 0.048 | 3.2 | 0.096 | 0.75 | 0.096 | 32 | 0.096 |
| AC-21-SS-4560-100912[b] | 10/9/2012 | 8.7 | 0.2 | 370 | 0.1 | 10 | 0.05 | 5 | 0.1 | 0.82 | 0.1 | 30 | 0.1 |
| AC-22-SS-0015-100912c | 10/9/2012 | 7.7 | 0.2 | 450 | 0.098 | 15 | 0.049 | 2.3 | 0.098 | 3.1 | 0.098 | 83 | 0.098 |
| AC-22-SS-1530-100912[c] | 10/9/2012 | 9.2 | 0.19 | 310 | 0.096 | 17 | 0.048 | 3.4 | 0.096 | 2.3 | 0.096 | 94 | 0.096 |
| AC-23-SS-0015-100912[c] | 10/9/2012 | 9.8 | 0.2 | 370 | 0.1 | 16 | 0.05 | 1.5 | 0.1 | 1.1 | 0.1 | 53 | 0.1 |
| AC-23-SS-1530-100912 | 10/9/2012 | 8.6 | 0.2 | 350 | 0.098 | 15 | 0.049 | 1.3 | 0.098 | 0.81 | 0.098 | 47 | 0.098 |
| AC-24-SS-1560-101012[d] | 10/10/2012 | 7 | 0.19 | 440 | 0.096 | 14 | 0.048 | 2.2 | 0.096 | 1 | 0.096 | 41 | 0.096 |
| AC-25-SS-15105-101012[d] | 10/10/2012 | 6.7 | 0.2 | 440 | 0.098 | 14 | 0.049 | 2.7 | 0.098 | 4.6 | 0.098 | 85 | 0.098 |
| AC-26-SS-15105-101012[d] | 10/10/2012 | 6.3 | 0.19 | 430 | 0.097 | 12 | 0.048 | 1.9 | 0.097 | 0.96 | 0.097 | 47 | 0.097 |
| AC-27-SS-1545-101012[d] | 10/10/2012 | 5 | 0.2 | 450 | 0.099 | 12 | 0.049 | 2.5 | 0.099 | 0.94 | 0.099 | 35 | 0.099 |
| AC-28-SS-1545-101012[d] | 10/10/2012 | 6.7 | 0.19 | 430 | 0.097 | 15 | 0.049 | 3.6 | 0.097 | 4.1 | 0.097 | 80 | 0.097 |
| BRA-01-SS-0015-100812 | 10/8/2012 | 5.7 | 0.2 | 370 | 0.098 | 12 | 0.049 | 0.67 | 0.098 | 0.57 | 0.098 | 39 | 0.098 |
| BRA-01-SS-1530-100812 | 10/8/2012 | 6 | 0.19 | 370 | 0.096 | 11 | 0.048 | 0.61 | 0.096 | 0.62 | 0.096 | 36 | 0.096 |
| BRA-02-SS-0015-100812 | 10/8/2012 | 5.6 | 0.2 | 450 | 0.099 | 13 | 0.05 | 0.61 | 0.099 | 0.56 | 0.099 | 37 | 0.099 |
| BRA-02-SS-1530-100812 | 10/8/2012 | 5.1 | 0.19 | 390 | 0.096 | 11 | 0.048 | 0.46 | 0.096 | 0.37 | 0.096 | 32 | 0.096 |
| BRA-03-SS-0015-100812 | 10/8/2012 | 8.7 | 0.19 | 260 | 0.097 | 17 | 0.048 | 0.88 | 0.097 | 0.7 | 0.097 | 62 | 0.097 |

## Table 4-14. Soil Sample Results: Indicator Metals (continued)

| | | Arsenic (mg kg$^{-1}$) | | Barium (mg kg$^{-1}$) | | Lead (mg kg$^{-1}$) | | Molybdenum (mg kg$^{-1}$) | | Selenium (mg kg$^{-1}$) | | Vanadium (mg kg$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **Date Collected** | **Result** | **PRL** | **Result** | **PRL** | **Result** | **PRL** | **Result** | **PRL** | **Result** | **PRL** | **Result** | **PRL** |
| BRA-03-SS-1530-100812 | 10/8/2012 | 9.2 | 0.19 | 200 | 0.097 | 17 | 0.048 | 0.97 | 0.097 | 0.54 | 0.097 | 74 | 0.097 |
| BRA-04-SS-0015-100812 | 10/8/2012 | 7.3 | 0.2 | 390 | 0.098 | 15 | 0.049 | 0.65 | 0.098 | 0.57 | 0.098 | 40 | 0.098 |
| BRA-04-SS-1530-100812 | 10/8/2012 | 7.4 | 0.19 | 370 | 0.097 | 14 | 0.048 | 0.65 | 0.097 | 0.56 | 0.097 | 40 | 0.097 |
| BRA-05-SS-0015-100812 | 10/8/2012 | 7.1 | 0.2 | 370 | 0.098 | 15 | 0.049 | 0.79 | 0.098 | 0.75 | 0.098 | 53 | 0.098 |
| BRA-05-SS-1530-100812 | 10/8/2012 | 6.3 | 0.19 | 360 | 0.096 | 13 | 0.048 | 0.72 | 0.096 | 0.58 | 0.096 | 44 | 0.096 |
| BRA-06-SS-0015-100812 | 10/8/2012 | 7 | 0.2 | 340 | 0.099 | 15 | 0.049 | 0.83 | 0.099 | 0.71 | 0.099 | 52 | 0.099 |
| BRA-06-SS-1530-100812 | 10/8/2012 | 6.1 | 0.19 | 360 | 0.096 | 13 | 0.048 | 0.74 | 0.096 | 0.51 | 0.096 | 46 | 0.096 |
| BRA-07-SS-0015-100812 | 10/8/2012 | 5.6 | 0.2 | 400 | 0.098 | 12 | 0.049 | 0.65 | 0.098 | 0.61 | 0.098 | 39 | 0.098 |
| BRA-07-SS-1530-100812 | 10/8/2012 | 8.7 | 0.2 | 270 | 0.098 | 17 | 0.049 | 1.1 | 0.098 | 0.73 | 0.098 | 72 | 0.098 |
| BRA-08-SS-0015-100812 | 10/8/2012 | 6.3 | 0.19 | 390 | 0.096 | 13 | 0.048 | 0.71 | 0.096 | 0.65 | 0.096 | 47 | 0.096 |
| BRA-08-SS-1530-100812 | 10/8/2012 | 6.8 | 0.19 | 330 | 0.096 | 14 | 0.048 | 0.82 | 0.096 | 0.64 | 0.096 | 53 | 0.096 |
| BRA-09-SS-0015-100812 | 10/8/2012 | 7.3 | 0.2 | 300 | 0.099 | 15 | 0.049 | 0.91 | 0.099 | 0.64 | 0.099 | 58 | 0.099 |
| BRA-09-SS-1530-100812 | 10/8/2012 | 6.5 | 0.2 | 330 | 0.098 | 15 | 0.049 | 0.73 | 0.098 | 0.59 | 0.098 | 51 | 0.098 |
| BRA-10-SS-0015-100812 | 10/8/2012 | 5.9 | 0.2 | 440 | 0.099 | 15 | 0.05 | 0.71 | 0.099 | 0.56 | 0.099 | 41 | 0.099 |
| BRA-10-SS-1530-100812 | 10/8/2012 | 6.5 | 0.19 | 400 | 0.097 | 14 | 0.048 | 0.66 | 0.097 | 0.43 | 0.097 | 46 | 0.097 |
| BRA-11-SS-0015-100812 | 10/8/2012 | 5.9 | 0.2 | 410 | 0.099 | 13 | 0.049 | 0.69 | 0.099 | 0.42 | 0.099 | 33 | 0.099 |
| BRA-11-SS-1530-100812 | 10/8/2012 | 4.7 | 0.2 | 410 | 0.098 | 13 | 0.049 | 0.67 | 0.098 | 0.47 | 0.098 | 32 | 0.098 |
| BRA-12-SS-0015-100812 | 10/8/2012 | 4.7 | 0.2 | 380 | 0.098 | 11 | 0.049 | 0.54 | 0.098 | 0.56 | 0.098 | 33 | 0.098 |
| BRA-12-SS-1530-100812 | 10/8/2012 | 5.7 | 0.19 | 420 | 0.097 | 12 | 0.049 | 0.65 | 0.097 | 0.54 | 0.097 | 39 | 0.097 |
| BRA-13-SS-0015-100812 | 10/8/2012 | 6.1 | 0.2 | 380 | 0.099 | 13 | 0.05 | 1.5 | 0.099 | 0.58 | 0.099 | 41 | 0.099 |
| BRA-13-SS-1530-100812 | 10/8/2012 | 5.7 | 0.2 | 380 | 0.099 | 12 | 0.05 | 0.68 | 0.099 | 0.57 | 0.099 | 43 | 0.099 |
| BRA-14-SS-0015-100812 | 10/8/2012 | 5.7 | 0.2 | 420 | 0.099 | 13 | 0.05 | 0.63 | 0.099 | 0.59 | 0.099 | 39 | 0.099 |
| BRA-14-SS-1530-100812 | 10/8/2012 | 6.3 | 0.19 | 390 | 0.097 | 13 | 0.048 | 0.72 | 0.097 | 0.67 | 0.097 | 43 | 0.097 |
| BRA-15-SS-0015-100812 | 10/8/2012 | 5 | 0.19 | 450 | 0.097 | 11 | 0.049 | 0.56 | 0.097 | 0.46 | 0.097 | 32 | 0.097 |
| BRA-15-SS-1530-100812 | 10/8/2012 | 4.5 | 0.19 | 420 | 0.097 | 10 | 0.049 | 0.48 | 0.097 | 0.47 | 0.097 | 29 | 0.097 |
| BRA-16-SS-0015-100812 [d] | 10/8/2012 | 4.9 | 0.2 | 440 | 0.098 | 11 | 0.049 | 0.57 | 0.098 | 0.51 | 0.098 | 31 | 0.098 |
| BRA-16-SS-1530-100812 [d] | 10/8/2012 | 4.5 | 0.2 | 440 | 0.098 | 10 | 0.049 | 0.52 | 0.098 | 0.49 | 0.098 | 28 | 0.098 |

## Table 4-14. Soil Sample Results: Indicator Metals (concluded)

Notes:
[a]The correct identifier for sample AC-16-SS-1555-101512 is AC-16-SS-55125-101612. [a]The correct identifiers for sample AC-16-SS-55125-101512 is AC-16-SS-1555-101612.
[b]The correct identifiers for samples AC-21-SS-0015-100912, AC-21-SS-1545-100912, and AC-21-SS-4560-100912 are AC-22-SS-0015-100912, AC-22-SS-1545-100912, and AC-22-SS-4560-100912, respectively.
[c]The correct identifiers for sample AC-22-SS-0015-100912 and AC-22-SS-1530-100912 are AC-21-SS-0015-100912 and AC-21-SS-1530-100912, respectively.
[d]Sample duplicate

mg $kg^{-1}$ = milligrams per kilogram
PRL = practical reporting limit

## Table 4-15. Summary statistics for Concentrations of Radionuclides in the Background Reference Area

| Parameter | K-40 (pCi $g^{-1}$) | Ra-226 (pCi $g^{-1}$) | Th-228 (pCi $g^{-1}$) | Th-230 (pCi $g^{-1}$) | Th-232 (pCi $g^{-1}$) | Uranium (pCi $g^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 15.7 | 0.9 | 1.1 | 0.9 | 1.0 | 1.4 |
| **Minimum** | 13.9 | 0.6 | 0.8 | 0.6 | 0.8 | 1.0 |
| **Maximum** | 17.5 | 1.2 | 1.7 | 1.6 | 1.5 | 1.8 |
| **σ** | 1.0 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| **n** | 30 | 30 | 30 | 30 | 30 | 30 |

Notes:
n = number of observations
pCi $g^{-1}$ = picocuries per gram
σ = standard deviation

## Table 4-16. Summary statistics for Concentrations of Radionuclides in Area A

| Parameter | K-40 (pCi $g^{-1}$) | Ra-226 (pCi $g^{-1}$) | Th-228 (pCi $g^{-1}$) | Th-230 (pCi $g^{-1}$) | Th-232 (pCi $g^{-1}$) | Uranium (pCi $g^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 16.5 | 62 | 0.9 | 88 | 0.9 | 87 |
| **Minimum** | 11.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.8 |
| **Maximum** | 22.2 | 255 | 1.8 | 478 | 1.8 | 378 |
| **σ** | 2.2 | 73 | 0.4 | 133 | 0.4 | 113 |
| **Median** | 16.8 | 33 | 0.8 | 37 | 0.8 | 37 |
| **Q1** | 15.5 | 2.1 | 0.7 | 1.3 | 0.7 | 2.4 |
| **Q3** | 17.9 | 112 | 1.2 | 110 | 1.2 | 133 |
| **n** | 33 | 33 | 33 | 33 | 33 | 33 |

Notes:
n = number of observations
pCi $g^{-1}$ = picocuries per gram
σ = standard deviation
Q1 = first quartile
Q3 = third quartile

## Table 4-17. Summary statistics for Concentrations of Radionuclides in Area B

| Parameter | K-40 (pCi $g^{-1}$) | Ra-226 (pCi $g^{-1}$) | Th-228 (pCi $g^{-1}$) | Th-230 (pCi $g^{-1}$) | Th-232 (pCi $g^{-1}$) | Uranium (pCi $g^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 14.7 | 0.8 | **0.7** | 0.9 | 0.6 | 1.1 |
| **Minimum** | 12.3 | 0.5 | 0.5 | 0.6 | 0.5 | 0.8 |
| **Maximum** | 16.4 | 1.4 | 1.0 | 1.6 | 0.9 | 1.8 |
| **σ** | 1.7 | 0.3 | 0.2 | 0.3 | 0.2 | 0.3 |
| **Median** | 15.4 | 0.8 | 0.6 | 0.8 | 0.6 | 1.1 |
| **Q1** | 12.9 | 0.7 | 0.6 | 0.7 | 0.5 | 0.9 |
| **Q3** | 16.1 | 0.9 | 0.8 | 1.0 | 0.7 | 1.3 |
| **n** | 10 | 10 | 10 | 10 | 10 | 10 |

Notes:
n = number of observations
pCi $g^{-1}$ = picocuries per gram
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

**Table 4-18. Summary statistics for Concentrations of Radionuclides in Area C**

| Parameter | K-40 (pCi $g^{-1}$) | Ra-226 (pCi $g^{-1}$) | Th-228 (pCi $g^{-1}$) | Th-230 (pCi $g^{-1}$) | Th-232 (pCi $g^{-1}$) | Uranium (pCi $g^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 15.3 | 18.2 | 1.0 | 13.2 | 0.9 | 18 |
| **Minimum** | 9.8 | 0.4 | 0.4 | 0.5 | 0.4 | 1.0 |
| **Maximum** | 19.2 | 129 | 1.7 | 141 | 1.5 | 203 |
| **Standard Deviation** | 1.9 | 29 | 0.3 | 28 | 0.3 | 38 |
| **Median** | 15.4 | 4.6 | 0.9 | 2.9 | 0.9 | 5.9 |
| **Q1** | 14.2 | 1.7 | 0.8 | 1.1 | 0.7 | 3.7 |
| **Q3** | 16.7 | 23.4 | 1.2 | 8.6 | 1.2 | 11.6 |
| **n** | 63 | 63 | 63 | 63 | 63 | 63 |

Notes:
n = number of observations
pCi $g^{-1}$ = picocuries per gram
σ = standard deviation
Q1 = first quartile
Q3 = third quartile

## Table 4-19. Static Gamma Count Rates and Associated Radium-226 Concentrations in Surface Soils

| Date | Surface Soil Sample Location | Ra-226 ($pCi\ g^{-1}$) | Gamma Count Rate ($c\ min^{-1}$) |
|---|---|---|---|
| 10/11/2012 | AA-02 | 1.13 | 19984 |
| 10/11/2012 | AB-01 | 0.8 | 18052 |
| 10/11/2012 | AB-02 | 1.44 | 20436 |
| 10/11/2012 | AB-03 | 0.617 | 12920 |
| 10/11/2012 | AB-04 | 1.14 | 14950 |
| 10/11/2012 | AB-05 | 0.84 | 19984 |
| 10/9/2012 | AC-01 | 39.9 | 54145 |
| 10/10/2012 | AC-02 | 55.9 | 106517 |
| 10/9/2012 | AC-03 | 6.76 | 29157 |
| 10/9/2012 | AC-04 | 9.3 | 37735 |
| 10/9/2012 | AC-05 | 18.2 | 43249 |
| 10/10/2012 | AC-07 | 39.4 | 98334 |
| 10/10/2012 | AC-08 | 129 | 197666 |
| 10/10/2012 | AC-09 | 2.88 | 33841 |
| 10/10/2012 | AC-10 | 113 | 187097 |
| 10/10/2012 | AC-11 | 8.27 | 33271 |
| 10/9/2012 | AC-12 | 8 | 26446 |
| 10/9/2012 | AC-13 | 22.7 | 24538 |
| 10/9/2012 | AC-14 | 12.9 | 41295 |
| 10/10/2012 | AC-15 | 45.7 | 90269 |
| 10/10/2012 | AC-17 | 66 | 102887 |
| 10/9/2012 | AC-18 | 3.21 | 20652 |
| 10/10/2012 | AC-19 | 115 | 43456 |
| 10/9/2012 | AC-20 | 7.49 | 36761 |
| 10/9/2012 | AC-21 | 9.1 | 43177 |
| 10/9/2012 | AC-22 | 28.8 | 29078 |
| 10/9/2012 | AC-23 | 30.8 | 32500 |

## Table 4-19. Static Gamma Count Rates and Associated Radium-226 Concentrations in Surface Soils (concluded)

| Date | Surface Soil Sample Location | Ra-226 (pCi $g^{-1}$) | Gamma Count Rate (c $min^{-1}$ ) |
|---|---|---|---|
| 10/8/2012 | BRA-01 | 0.94 | 13519 |
| 10/8/2012 | BRA-02 | 0.77 | 12866 |
| 10/8/2012 | BRA-03 | 1.23 | 14595 |
| 10/8/2012 | BRA-04 | 0.88 | 14214 |
| 10/8/2012 | BRA-05 | 0.97 | 13452 |
| 10/8/2012 | BRA-06 | 1.09 | 13387 |
| 10/8/2012 | BRA-07 | 0.92 | 12928 |
| 10/8/2012 | BRA-08 | 0.91 | 14107 |
| 10/8/2012 | BRA-09 | 1.1 | 12510 |
| 10/8/2012 | BRA-10 | 0.87 | 14182 |
| 10/8/2012 | BRA-11 | 0.78 | 12727 |
| 10/8/2012 | BRA-12 | 0.686 | 13304 |
| 10/8/2012 | BRA-13 | 0.9 | 12656 |
| 10/8/2012 | BRA-14 | 0.86 | 12829 |
| 10/8/2012 | BRA-15 | 0.82 | 11490 |

Notes:
c $min^{-1}$ = counts per minute
pCi $g^{-1}$ = picocuries per gram

## Table 4-20. Summary Statistics for Concentrations of Indicator Metals in the Background Reference Area

| Parameter | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 6.3 | 372 | 13 | 0.7 | 0.57 | 44 |
| **Minimum** | 4.5 | 200 | 10 | 0.46 | 0.37 | 29 |
| **Maximum** | 9.2 | 450 | 17 | 1.5 | 0.75 | 74 |
| **σ** | 1.2 | 56 | 2 | 0.2 | 0.09 | 11 |
| **n** | 30 | 30 | 30 | 30 | 30 | 30 |

Notes:
n = number of observations
mg kg$^{-1}$ = milligrams per kilogram
σ = standard deviation

## Table 4-21. Summary Statistics for Concentrations of Indicator Metals in Area A

| Parameter | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 8.1 | 449 | 16 | 7.35 | 15.4 | 106 |
| **Minimum** | 1.9 | 170 | 7.5 | 0.68 | 0.2 | 11 |
| **Maximum** | 20 | 790 | 23 | 56 | 68 | 290 |
| **σ** | 4.1 | 119 | 4 | 11.24 | 20.3 | 79 |
| **Median** | 7.4 | 450 | 16 | 3.0 | 5.1 | 82 |
| **Q1** | 5.0 | 390 | 13 | 1.2 | 0.9 | 45 |
| **Q3** | 10.0 | 530 | 19 | 7.3 | 21 | 140 |
| **n** | 33 | 33 | 33 | 33 | 33 | 33 |

Notes:
n = number of observations
mg kg$^{-1}$ = milligrams per kilogram
σ = standard deviation

## Table 4-22. Summary Statistics for Concentrations of Indicator Metals in Area B

| Parameter | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 4.0 | 417 | 11 | 1.09 | 0.51 | 28 |
| **Minimum** | 2.5 | 360 | 9 | 0.64 | 0.33 | 17 |
| **Maximum** | 6.1 | 500 | 13 | 2.00 | 1.10 | 44 |
| **σ** | 1.2 | 48 | 1 | 0.51 | 0.22 | 9 |
| **Median** | 3.9 | 410 | 12 | 0.88 | 0.47 | 26 |
| **Q1** | 3.2 | 393 | 10 | 0.75 | 0.40 | 21 |
| **Q3** | 4.4 | 418 | 12 | 1.21 | 0.53 | 30 |
| **n** | 10 | 10 | 10 | 10 | 10 | 10 |

Notes:
mg kg$^{-1}$ = milligrams per kilogram
n = number of observations
Q1 = first quartile
Q3 = third quartile
σ = standard deviation

## Table 4-23. Summary Statistics for Concentrations of Indicator Metals in Area C

| Parameter | Arsenic (mg $kg^{-1}$) | Barium (mg $kg^{-1}$) | Lead (mg $kg^{-1}$) | Molybdenum (mg $kg^{-1}$) | Selenium (mg $kg^{-1}$) | Vanadium (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|
| **Mean** | 6.5 | 399 | 14 | 2.4 | 2.5 | 54 |
| **Minimum** | 3.0 | 290 | 8 | 0.61 | 0.47 | 18 |
| **Maximum** | 9.8 | 560 | 20 | 14 | 27 | 190 |
| **σ** | 1.8 | 52 | 3 | 2.44 | 3.97 | 27 |
| **Median** | 6.4 | 400 | 14 | 1.60 | 1.10 | 49 |
| **Q1** | 5.2 | 370 | 11 | 1.25 | 0.71 | 37 |
| **Q3** | 8.2 | 435 | 15 | 2.45 | 2.10 | 63 |
| **n** | 63 | 63 | 63 | 63 | 63 | 63 |

Notes:
mg $kg^{-1}$ = milligrams per kilogram
n = number of observations
σ = standard deviation
Q1 = first quartile
Q3 = third quartile

## Table 4-24. Estimated Depths of Mine-Related Material in the Project Area

| | Depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| Boring Location | Bck | 5 pCi $g^{-1}$ + Bkg | Average to Bkg | Average to 5 pCi $g^{-1}$ Ra-226+ Bkg | Shape No. | Note | Justification for Shape |
| AC-20 | 0.62 | 0.15 | 0.51 | 0.3 | 1 | a | Downstream arroyo offsite Area C. Boundary determined by the gamma survey and fence. |
| AC-21 | 0.6 | 0.6 | | | | | |
| AC-22 | 0.3 | 0.15 | | | | | |
| AC-03 | 0.3 | 0.3 | 0.39 | 0.15 | 2 | A | Downstream arroyo area on Hecla property. Boundary determined by the gamma survey and fence. |
| AC-04 | 0.4 | 0.15 | | | | | |
| AC-05 | 0.44 | 0.15 | | | | | |
| AC-12 | 0.3 | 0.15 | | | | | |
| AC-13 | 0.5 | 0.15 | | | | | |
| AC-14 | 0.4 | 0.15 | | | | | |
| AC-03 | 0.3 | 0.15 | 0.30 | 0.15 | 3 | a,b | Mid-stream arroyo where flows are faster and the channel is more defined than in Shapes 1 and 2. Depth to cutoff value likely different than in Shapes 1 and 2 |
| AC-06 | 1.7 | 1.45 | 1.15 | 0.8 | 4 | a,b | Shape is upstream of the road culvert, which acts as a flow restrictor. Shape has different zones of potential depths. Shape boundaries are defined by the gamma survey and outer edges of the arroyo channel. |
| AC-11 | 0.6 | 0.15 | | | | | |
| AC-01 | 0.5 | 0.15 | 0.37 | 0.15 | 5 | c | Topography in this shape is a natural hillside. The outer boundaries were determined by the gamma survey and adjusted slightly by the natural topography. Source is potentially a combination of historical wind-blown and associated with the pipeline. |
| AC-02 | 0.6 | 0.15 | | | | | |
| AC-18 | 0 | NA | | | | | |
| AC-19 | 0.44 | 0.15 | | | | | |
| AC-23 | 0.3 | 0.3 | | | | | |
| AC-16 | 0.6 | 0.55 | 0.98 | 0.8 | 6 | c | Similar to Shape 5, but segregated because it is distinct topographically. |
| AC-17 | 1.35 | 1.05 | | | | | |

## Table 4-24. Estimated Depths of Mine-Related Material in Areas A and C (continued)

<table>
<tr><th></th><th colspan="4">Depth (m)</th><th></th><th></th><th></th></tr>
<tr><th>Boring Location</th><th>Bkg</th><th>5 pCi g$^{-1}$ + Bkg</th><th>Average to Bkg</th><th>Average to 5 pCi g$^{-1}$ Ra-226+ Bkg</th><th>Shape No.</th><th>Note</th><th>Justification for Shape</th></tr>
<tr><td>NA</td><td>0.15</td><td>0.15</td><td>0.15</td><td>0.15</td><td>7</td><td>c</td><td>Similar to Shape 5, but segregated because it is a distinct topographically. A depth of 0.15 m was assumed, because no borings were advanced herein.</td></tr>
<tr><td>AC-09</td><td>0.12</td><td>0</td><td>0.12</td><td>0</td><td>8b</td><td>c</td><td rowspan="2">Shape location is just south of the access road. It may have been used for ore storage and contains waste rock. Boundaries are determined by the gamma survey, road, fence line, and edge of arroyo.</td></tr>
<tr><td>AC-10</td><td>1</td><td>0.9</td><td>1.0</td><td>0.9</td><td>8a</td><td>c</td></tr>
<tr><td>AC-07</td><td>1.2</td><td>1.05</td><td rowspan="2">0.90</td><td rowspan="2">0.83</td><td rowspan="2">9</td><td rowspan="2">c</td><td rowspan="2">Shape may have been used for ore storage and contains waste rock and uninhabited residence. Boundaries are determined by the gamma survey, road, and fence lines.</td></tr>
<tr><td>AC-08</td><td>0.6</td><td>0.6</td></tr>
<tr><td>AC-08</td><td>0.6</td><td>0.6</td><td rowspan="4">0.69</td><td rowspan="4">0.64</td><td rowspan="4">10</td><td rowspan="4">d</td><td rowspan="4">Road</td></tr>
<tr><td>AC-09</td><td>0.12</td><td>0</td></tr>
<tr><td>AC-10</td><td>1</td><td>0.9</td></tr>
<tr><td>AC-15</td><td>1.05</td><td>1.05</td></tr>
<tr><td>NA</td><td>0.15</td><td>0.15</td><td>0.15</td><td>0</td><td>11</td><td>c</td><td>Topography in this shape is a natural hillside. Boundary is defined by the gamma survey, fence line and the steep topography to the north. A depth of 0.15 m was assumed and no borings were advanced herein.</td></tr>
<tr><td>NA</td><td>0.58</td><td>0.4</td><td>0.58</td><td>0.4</td><td>12</td><td>g</td><td>Shape is upstream arroyo, defined by the upper edge of the arroyo. No borings were advanced herein. The depth was assumed at 0.5 times that of Shape 4.</td></tr>
</table>

## Table 4-24. Estimated Depths of Mine-Related Material in Areas A and C (continued)

| | Estimated Depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| Boring Location | Background | 5 pCi $g^{-1}$ Radium-226 + Background | Average to Background | Average to 5 pCi $g^{-1}$ Radium-226+ Background | Shape No. | Note | Justification for Shape |
| NA | 0.15 | 0.15 | 0.15 | 0.15 | 13 | c | Shape is upstream of historical mining operations. Source is expected to be historical wind deposition. A depth of 0.15 m was assumed and no borings were advanced herein. |
| NA | 0.15 | 0.15 | 0.15 | 0.15 | 14 | c | Topography in this shape is natural hillsides. It is adjacent to upstream section of the arroyo. Source is expected to be historical wind deposition. Boundary defined by the gamma survey and top of the arroyo. A depth of 0.15 m was assumed and no borings were advanced herein. |
| NA | 0.15 | 0.15 | 0.15 | 0.15 | 15 | c | Topography in this shape is natural hillsides. It is adjacent to upstream section of the arroyo. Source is expected to be wind deposition. Boundary defined by the gamma survey and top of the arroyo. A depth of 0.15 m was assumed and no borings were advanced herein. |
| NA | 0.3 | 0.3 | 0.3 | 0.3 | 16 | d | Shape is extension of a historical mine service road. A depth of 0.3 m was assumed for possible spread by trucks. No borings were advanced herein. |
| NA | 0.58 | 0.4 | 0.58 | 0.4 | 17 | g | Shape characterized by erosion channel .The depth was assumed at 0.5 times that of Shape 4, because no borings were advanced herein. |

## Table 4-24. Estimated Depths of Mine-Related Material in Areas A and C (continued)

| | Estimated depth (m) | | | | | | |
|---|---|---|---|---|---|---|---|
| Boring Location | Background | 5 pCi $g^{-1}$ Radium-226 + Background | Average to Background | Average to 5 pCi $g^{-1}$ Radium-226+ Background | Shape No. | Note | Justification for Shape |
| AA-05 | 0 | 0 | 0.15 | 0.15 | 18 | e | Shape consists of natural alluvial deposits from surrounding Mancos Shale cliffs. Source is expected to be historic wind deposition. |
| AA-02 | 0 | 0 | 0.15 | 0.15 | 19 | e | Similar to Shape 18, but in a different location of Area A. Consists of natural alluvial deposits from surrounding Mancos Shale cliffs. Source is expected to be historic wind deposition. |
| AA-01 | 1.3 | 1.15 | NA | NA | 20 | f | Location of original mine facilities. It is now relatively flat. Boundaries determined by the gamma survey and an evaluation of historical photos. |
| AA-03 | 2 | 1.45 | | | | | |
| AA-11 | 1.9 | 1.9 | | | | | |
| AA-12 | 1.7 | 1.7 | | | | | |
| AA-04 | 3 | 2.05 | NA | NA | 21 | f | Shape contains deepest profile of NORM-affected mine-related materials and contains the sedimentation ponds. Boundaries defined by gamma survey, top of the arroyo, natural slopes, and an evaluation of historical photos. |
| AA-06 | 3 | 3 | | | | | |
| AA-07 | 4.15 | 4.15 | | | | | |
| AA-08 | 6 | 5.65 | | | | | |
| AA-09 | 7.5 | 7.5 | | | | | |
| AA-10 | 4.3 | 4.3 | | | | | |

## Table 4-24. Estimated Depths of Mine-Related Material in Areas A and C (concluded)

Notes:
[a]This shape has relatively uniform topography and the down-hole measurements in the three borings reach their respective cutoff values. The average estimated depth was obtained from soil borings advanced therein.
[b]Shapes 3 and 4 consist of arroyo channels and drainage areas. The estimated depth of mine-related material is likely to be deepest in the primary arroyo. AC-06 and AC-11are located at the bottom of the arroyo. Using the average of these two depths for the whole shape, which includes areas with higher elevation, yields a conservative volume estimate.
[c]The topography in these shapes consists of natural, broad slopes. The source is either wind-deposited or associated with the pipeline. Given the uniform topography, we used an average estimated depth obtained from the soil borings.
[d]These shapes consist of the existing roadways and areas adjacent to the road. Where no data are available the depth is assumed at 0.3 m. The average estimated depth from the soil borings, where available.
[e]Down-hole measurements and radium-226 concentrations were similar to background values in the soil borings in these shapes. However, the GPS-based gamma survey revealed some isolated areas with elevated gamma count rates. The estimated depth of mine-related material in these shapes was assumed at 6 in.
[f]The average estimated depth for these shapes is provided only for information. They were not used in the volume calculations for Shapes 20 and 21, because the topography and extent mine-related material is relatively more complex. Please refer to the text for the method used to estimate volumes therein.
[g]Surface flows in upstream portions of arroyos are expected to have higher energy and deposit less sediment. The estimated depth of mine-related material is, therefore, assumed at 1/2 the value of those of downstream arroyo channels.

bkg - background
m = meter
NA = not applicable
pCi $g^{-1}$ = picocuries per gram
Ra-226 – radium-226

**Table 4-25. Volume Estimate Calculation**
**(Delineation to 5 $pCi/g^{-1}$ Plus Background Radium-226 in Soil)**

| Shape | Description | Average Estimated depth (m)[a] | Surface Area ($m^2$) | Volume ($m^3$) |
|---|---|---|---|---|
| 1 | Arroyo Wash (Downstream) | 0.3 | 49221 | 14709 |
| 2 | Arroyo Wash (Downstream) | 0.2 | 37744 | 6560 |
| 3 | Arroyo Channel (Midstream) | 0.1 | 24018 | 3593 |
| 4 | Arroyo Channel (Midstream) | 0.8 | 17381 | 13884 |
| 5 | Natural hillside | 0.1 | 51187 | 7645 |
| 6 | Natural hillside | 0.8 | 0 | 0 |
| 7 | Natural hillside | 0.2 | 0 | 0 |
| 8a | Natural hillside | 0.9 | 13393 | 12049 |
| 8b | Natural hillside | 0.2 | 7580 | 1162 |
| 9 | Ranch House Area | 0.8 | 45192 | 37332 |
| 10 | Road Alignment | 0.7 | 15820 | 10956 |
| 11 | Natural hillside | 0.2 | 14620 | 2232 |
| 12 | Arroyo Channel (Upstream) | 0.4 | 8067 | 3226 |
| 13 | Arroyo Channel (Upstream) | 0.2 | 2617 | 405 |
| 14 | Natural hillside | 0.2 | 12281 | 1873 |
| 15 | Natural hillside | 0.2 | 1850 | 283 |
| 16 | Road Alignment | 0.3 | 2379 | 726 |
| 17 | Arroyo channel | 0.4 | 0 | 0 |
| 18 | Natural hillside | 0.2 | 3626 | 558 |
| 19 | Natural hillside | 0.2 | 0 | 0 |
| 20 | Mine facility area | NA | 25788 | 34683 |
| 21 | Mine sedimentation pond area | NA | 33216 | 113945 |
| | | | **Total** | **265,900** |

Notes:
[a]Depths estimated as described in Table 4-24 and Section 3.5.
m = meters
NA = not applicable

## Table 4-26. Volume Estimate Calculation (Delineation to Background Concentration of Radium-226)

| Shape | Description | Average Estimated depth (m) | Surface Area ($m^2$) | Volume ($m^3$) |
|---|---|---|---|---|
| 1 | Arroyo Wash (Downstream) | 1.66 | 88931 | 45061 |
| 2 | Arroyo Wash (Downstream) | 1.28 | 65804 | 25665 |
| 3 | Arroyo Channel (Midstream) | 0.98 | 44486 | 13349 |
| 4 | Arroyo Channel (Midstream) | 3.77 | 21716 | 24977 |
| 5 | Natural hillside | 1.21 | 76806 | 28265 |
| 6 | Natural hillside | 3.20 | 28491 | 27783 |
| 7 | Natural hillside | 0.50 | 20324 | 3104 |
| 8a | Natural hillside | 3.28 | 10606 | 10612 |
| 8b | Natural hillside | 0.39 | 7582 | 917 |
| 9 | Ranch House Area | 2.95 | 60544 | 54495 |
| 10 | Road Alignment | 2.27 | 50492 | 34969 |
| 11 | Natural hillside | 0.50 | 43111 | 6575 |
| 12 | Arroyo Channel (Upstream) | 1.88 | 8132 | 4664 |
| 13 | Arroyo Channel (Upstream) | 0.50 | 6665 | 1017 |
| 14 | Natural hillside | 0.50 | 31490 | 4801 |
| 15 | Natural hillside | 0.50 | 11215 | 1713 |
| 16 | Road Alignment | 1.00 | 6077 | 1858 |
| 17 | Arroyo channel | 1.88 | 8309 | 4763 |
| 18 | Natural hillside | 0.50 | 9156 | 1399 |
| 19 | Natural hillside | 0.50 | 13577 | 2072 |
| 20 | Mine facility | NA | 24854 | 34683 |
| 21 | Mine sedimentation ponds | NA | 38213 | 113945 |
| | | | Total | **446,800 $m^3$** |

Notes:
[a]Depths estimated as described in Table 4-24 and Section 3.5.
m = meters
NA = not applicable

## Table 4-27. Relative Percent Differences for Indicator Metals in Sample Replicates

| Sample ID | Date Collected | Arsenic ($mg\ kg^{-1}$) | Barium ($mg\ kg^{-1}$) | Lead ($mg\ kg^{-1}$) | Molybdenum ($mg\ kg^{-1}$) | Selenium ($mg\ kg^{-1}$) | Vanadium ($mg\ kg^{-1}$) | Uranium ($mg\ kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| AC-02-SS-1560-100912 | 10/10/2012 | 7.2 | 390 | 14 | 2.2 | 1 | 43 | 9.4 |
| AC-24-SS-1560-101012 | 10/10/2012 | 7 | 440 | 14 | 2.2 | 1 | 41 | 8.3 |
| | **RPD** | **2.8** | **12.0** | **0.0** | **0.0** | **0.0** | **4.8** | **12.4** |
| AC-07-SS-15105-101012 | 10/10/2012 | 6.8 | 410 | 15 | 8.2 | 6.3 | 87 | 150 |
| AC-28-SS-1545-101012 | 10/10/2012 | 6.7 | 430 | 15 | 3.6 | 4.1 | 80 | 97 |
| | **RPD** | **1.5** | **4.8** | **0.0** | **78.0** | **42.3** | **8.4** | **42.9** |
| AC-11-1545-101012 | 10/10/2012 | 5.1 | 320 | 8.2 | 2.5 | 0.47 | 20 | 7.7 |
| AC-27-SS-1545-101012 | 10/10/2012 | 5 | 450 | 12 | 2.5 | 0.94 | 35 | 11 |
| | **RPD** | **2.0** | **33.8** | **37.6** | **0.0** | **66.7** | **54.5** | **35.3** |
| AC-15-22-15105-101012 | 10/10/2012 | 7.4 | 420 | 20 | 5.6 | 4.8 | 86 | 190 |
| AC-25-SS-15105-101012 | 10/10/2012 | 6.7 | 440 | 14 | 2.7 | 4.6 | 85 | 66 |
| | **RPD** | **9.9** | **4.7** | **35.3** | **69.9** | **4.3** | **1.2** | **96.9** |
| AC-17-SS-15105-101012 | 10/10/2012 | 6.4 | 450 | 12 | 1.5 | 0.85 | 45 | 9 |
| AC-26-SS-15105-101012 | 10/10/2012 | 6.3 | 430 | 12 | 1.9 | 0.96 | 47 | 9.2 |
| | **RPD** | **1.6** | **4.5** | **0.0** | **23.5** | **12.2** | **4.3** | **2.2** |
| BRA-15-SS-0015-100812 | 10/8/2012 | 5 | 450 | 11 | 0.56 | 0.46 | 32 | 1.7 |
| BRA-16-SS-0015-100812 | 10/8/2012 | 4.9 | 440 | 11 | 0.57 | 0.51 | 31 | 1.7 |
| | **RPD** | **2.0** | **2.2** | **0.0** | **1.8** | **10.3** | **3.2** | **0.0** |
| BRA-15-SS-1530-100812 | 10/8/2012 | 4.5 | 420 | 10 | 0.48 | 0.47 | 29 | 1.6 |
| BRA-16-SS-1530-100812 | 10/8/2012 | 4.5 | 440 | 10 | 0.52 | 0.49 | 28 | 1.6 |
| | **RPD** | **0.0** | **4.7** | **0.0** | **8.0** | **4.2** | **3.5** | **0.0** |

Notes:
$mg\ kg^{-1}$ = milligrams per kilogram
RPD = relative percent difference

## Table 4-28. Replicate Error Ratios for Radionuclides in Sample Replicates

| Sample ID | Date Collected | Potassium-40 ($pCi\ g^{-1}$) Result | Potassium-40 TPU | Radium-226 ($pCi\ g^{-1}$) Result | Radium-226 TPU | Thorium-228 ($pCi\ g^{-1}$) Result | Thorium-228 TPU | Thorium-230 ($pCi\ g^{-1}$) Result | Thorium-230 TPU | Thorium-232 ($pCi\ g^{-1}$) Result | Thorium-232 TPU |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AC-02-SS-1560-100912 | 10/10/2012 | 16.5 | 2.2 | 1.59 | 0.2 | 0.96 | 0.18 | 0.88 | 0.17 | 0.96 | 0.18 |
| AC-24-SS-1560-101012 | 10/10/2012 | 15.9 | 2.1 | 1.85 | 0.23 | 1.06 | 0.24 | 1.12 | 0.23 | 1.14 | 0.23 |
| | **RER** | **0.03** | | **0.10** | | **0.20** | | **0.21** | | **0.17** | |
| AC-07-SS-15105-101012 | 10/10/2012 | 15.4 | 2.2 | 55.1 | 6.5 | 0.92 | 0.17 | 58.2 | 9 | 0.93 | 0.17 |
| AC-28-SS-1545-101012 | 10/10/2012 | 14.6 | 2.1 | 42.2 | 4.9 | 1.05 | 0.19 | 51.2 | 8 | 1.02 | 0.19 |
| | **RER** | **0.03** | | **0.20** | | **0.08** | | **0.08** | | **0.08** | |
| AC-11-1545-101012 | 10/10/2012 | 9.8 | 1.4 | 0.83 | 0.11 | 0.52 | 0.12 | 0.69 | 0.14 | 0.43 | 0.09 |
| AC-27-SS-1545-101012 | 10/10/2012 | 13 | 1.8 | 3.79 | 0.46 | 0.76 | 0.15 | 2.68 | 0.44 | 0.72 | 0.14 |
| | **RER** | **0.18** | | **0.74** | | **0.16** | | **0.65** | | **0.30** | |
| AC-15-22-15105-101012 | 10/10/2012 | 16.1 | 2.3 | 58.1 | 6.8 | 0.96 | 0.19 | 88 | 14 | 0.92 | 0.17 |
| AC-25-SS-15105-101012 | 10/10/2012 | 16.4 | 2.2 | 45.7 | 5.3 | 0.97 | 0.19 | 30.1 | 4.7 | 0.96 | 0.18 |
| | **RER** | **0.03** | | **0.17** | | **0.00** | | **0.63** | | **0.04** | |
| AC-17-SS-15105-101012 | 10/10/2012 | 13.9 | 2 | 35.9 | 4.2 | 0.94 | 0.18 | 8.9 | 1.4 | 0.93 | 0.17 |
| AC-26-SS-15105-101012 | 10/10/2012 | 14.6 | 2.2 | 38.2 | 4.5 | 0.98 | 0.19 | 10 | 1.6 | 0.8 | 0.15 |
| | **RER** | **0.07** | | **0.05** | | **0.04** | | **0.09** | | **0.09** | |
| BRA-15-SS-0015-100812 | 10/8/2012 | 14 | 1.9 | 0.82 | 0.11 | 0.81 | 0.16 | 0.75 | 0.15 | 0.88 | 0.16 |
| BRA-16-SS-0015-100812 | 10/8/2012 | 14.7 | 2 | 0.712 | 0.097 | 0.86 | 0.17 | 0.7 | 0.14 | 0.84 | 0.15 |
| | **RER** | **0.04** | | **0.09** | | **0.04** | | **0.05** | | **0.05** | |
| BRA-15-SS-1530-100812 | 10/8/2012 | 14.9 | 2 | 0.71 | 0.097 | 0.89 | 0.17 | 0.66 | 0.13 | 0.78 | 0.15 |
| BRA-16-SS-1530-100812 | 10/8/2012 | 14.6 | 2 | 0.707 | 0.098 | 1.04 | 0.25 | 0.59 | 0.17 | 0.69 | 0.17 |
| | **RER** | **0.00** | | **0.01** | | **0.26** | | **0.19** | | **0.09** | |

Notes:
$pCi\ g^{-1}$ = picocuries per gram
RER = replicate error ratio
TPU = total propagated uncertainty

## Figures

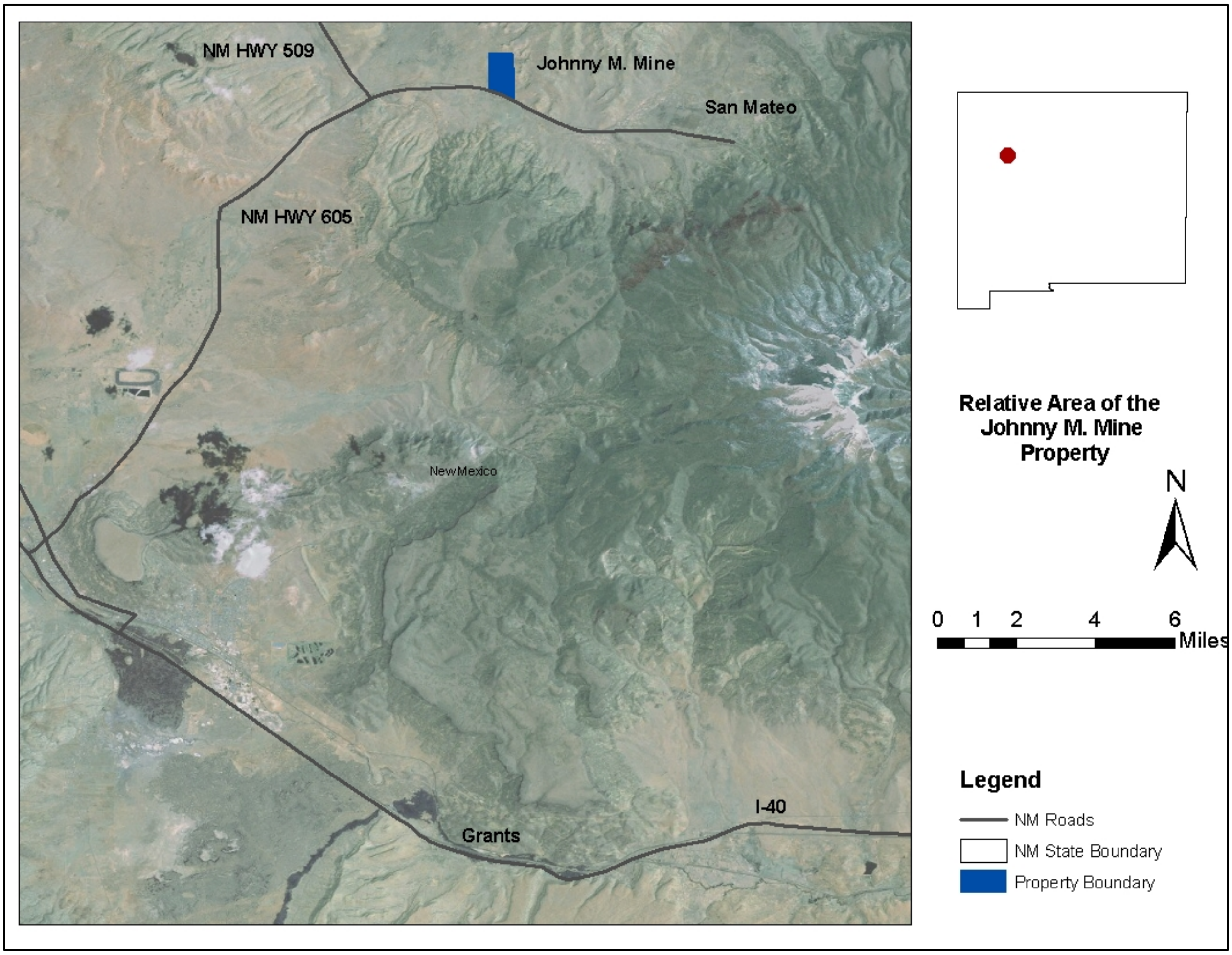



**Figure 1-1. Location of the Johnny M Mine and Adjacent Properties**

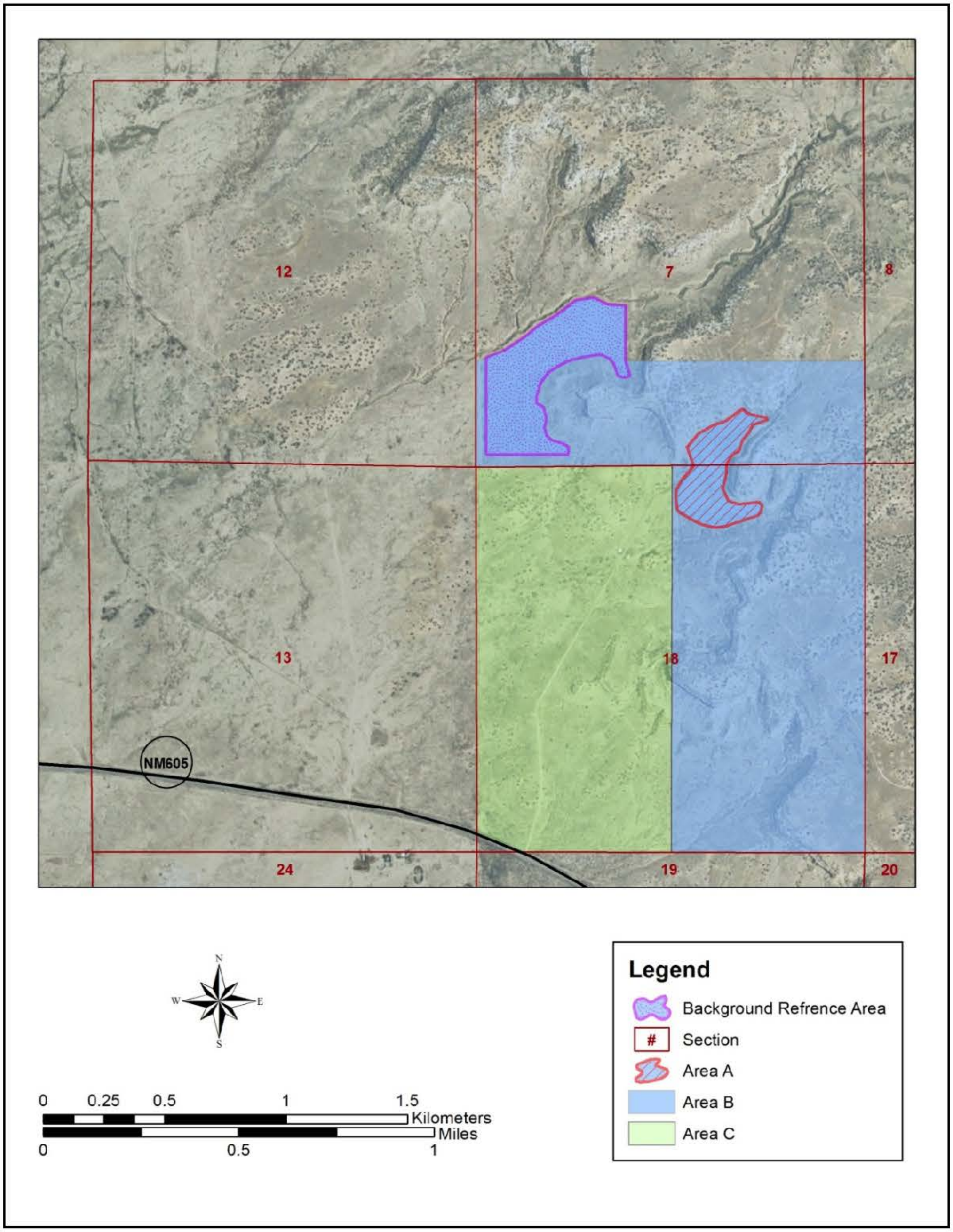



**Figure 1-2. Areas A, B, and C with Background Reference Area**

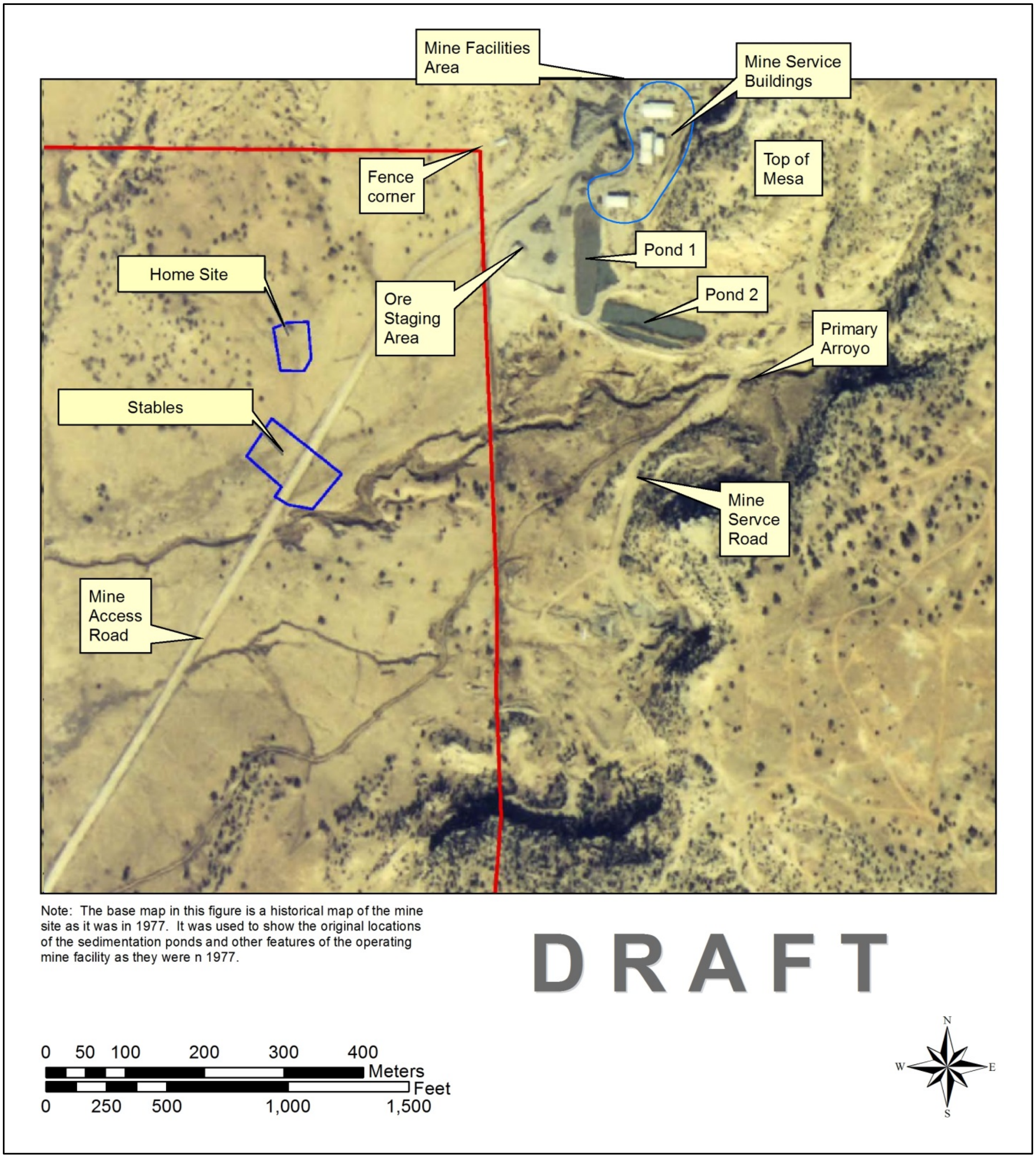



**Figure 3-1. 1977 Historical Aerial Photo with Site Features**

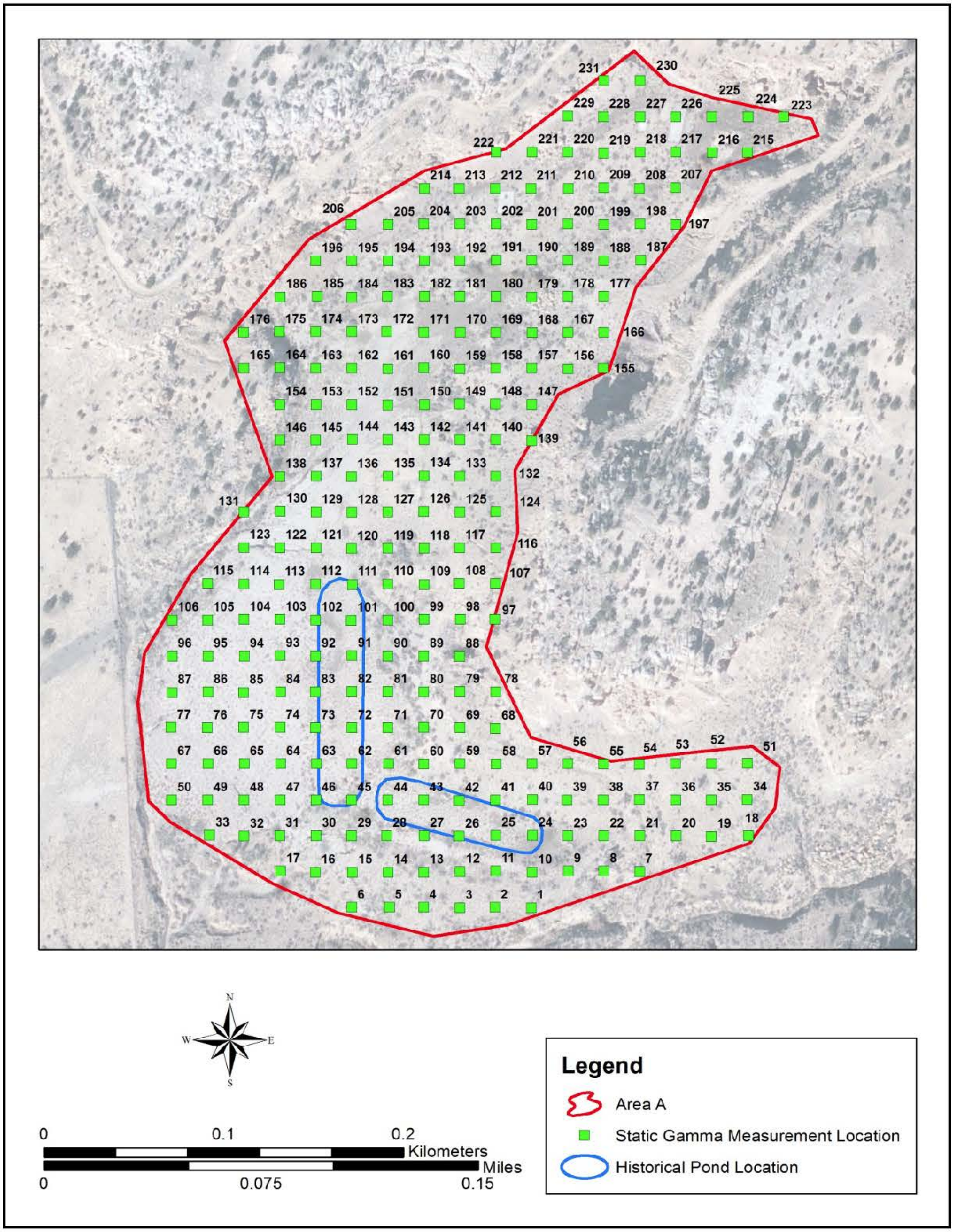



**Figure 3-2. Static Measurement Locations in Area A**

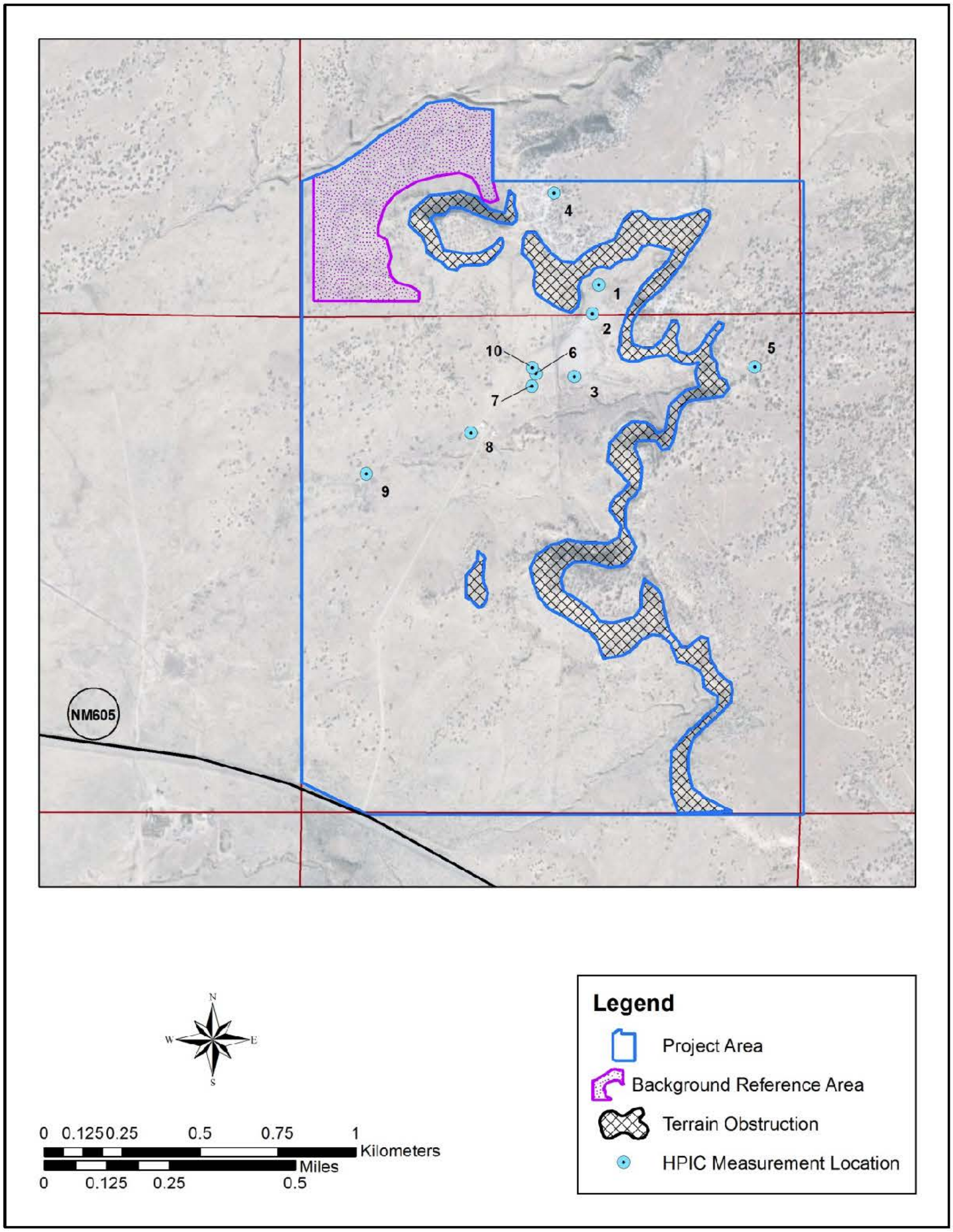



**Figure 3-3. Locations of Gamma Count and Exposure Rate Measurements**

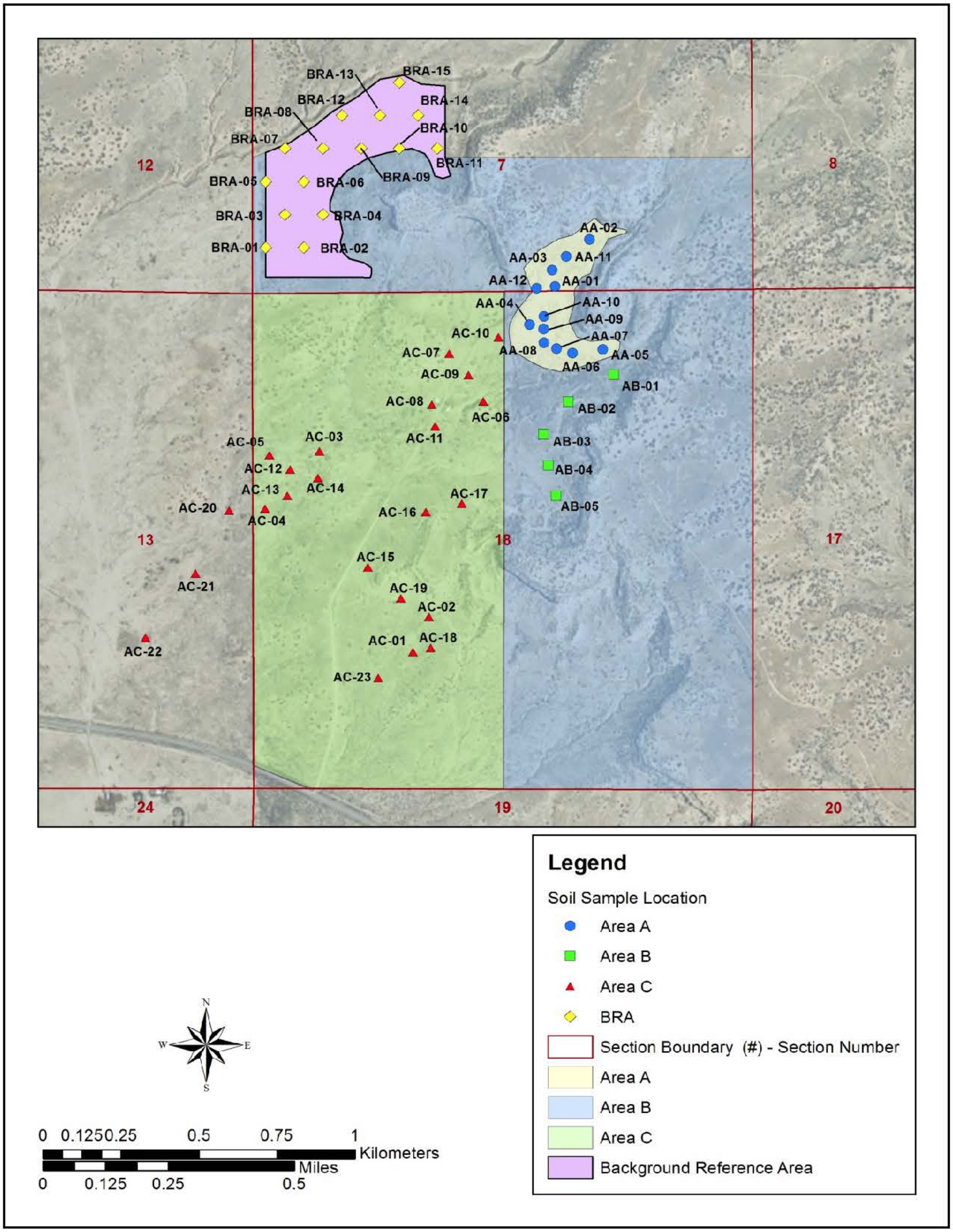



**Figure 3-4. Project Area-Wide Radionuclide/Indicator Metals Soil Sample Locations**

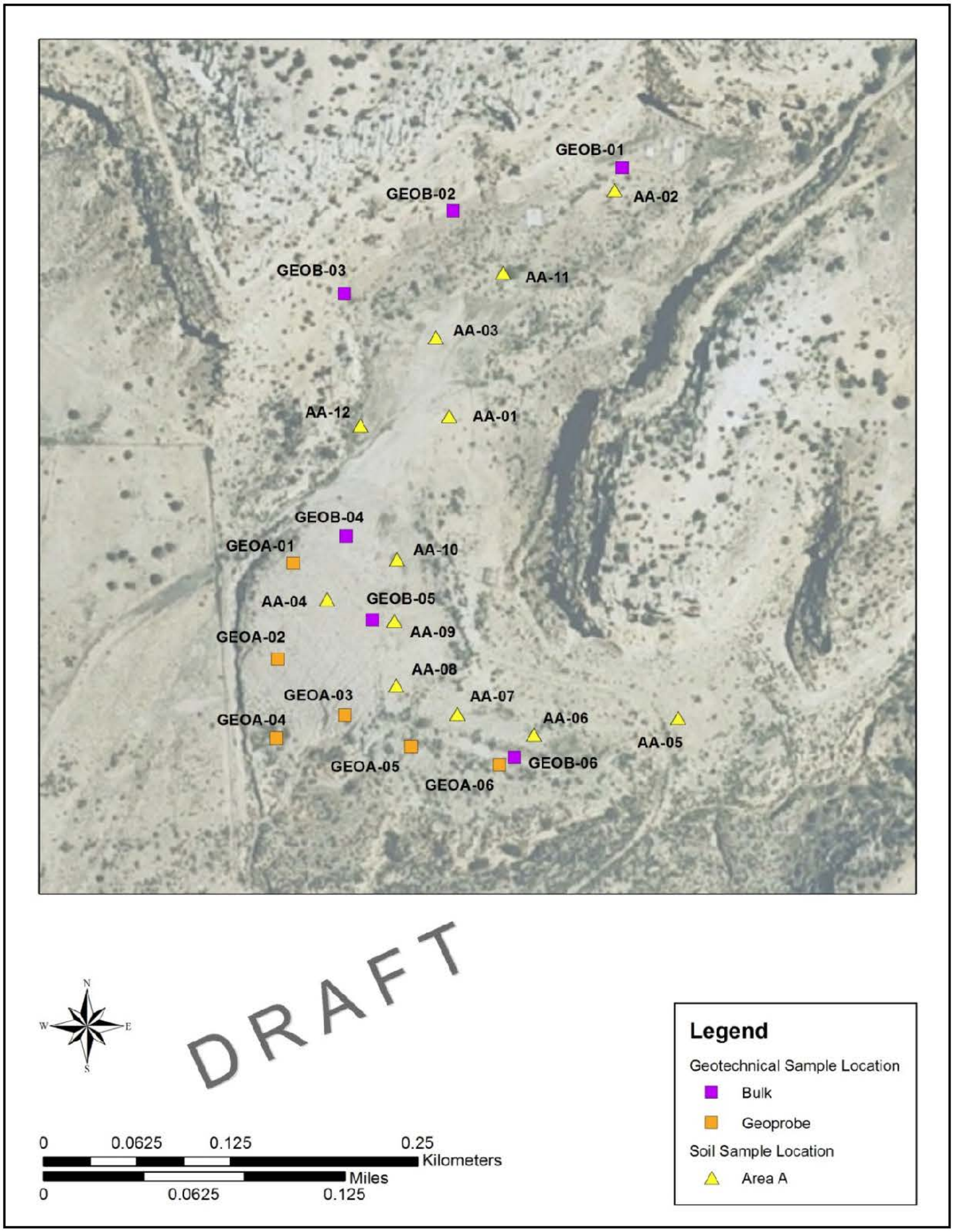



**Figure 3-5. Area A Soil Sample Locations**

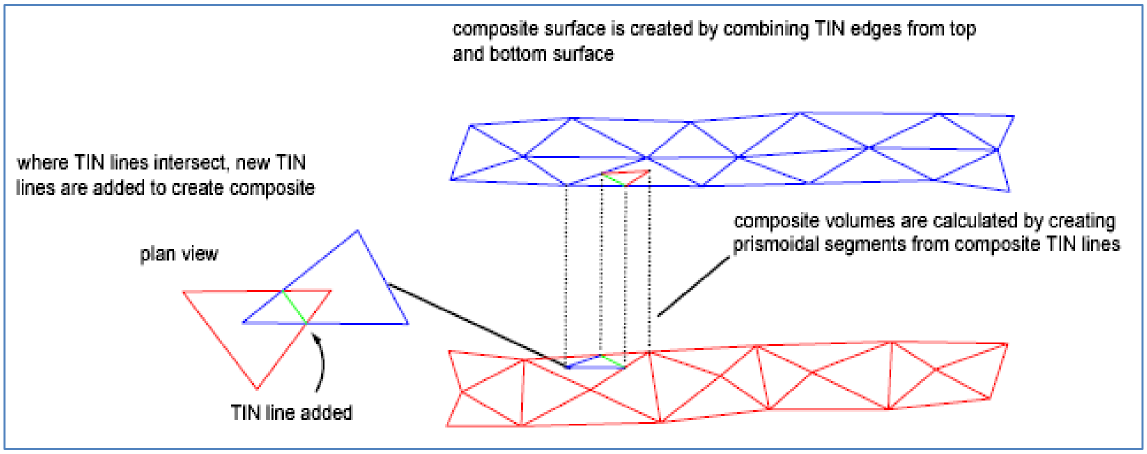



**Figure 3-6. Autocad Volume "Analyze" Method**

**Figure 3-7. Photograph of Temporary Silt Fence**

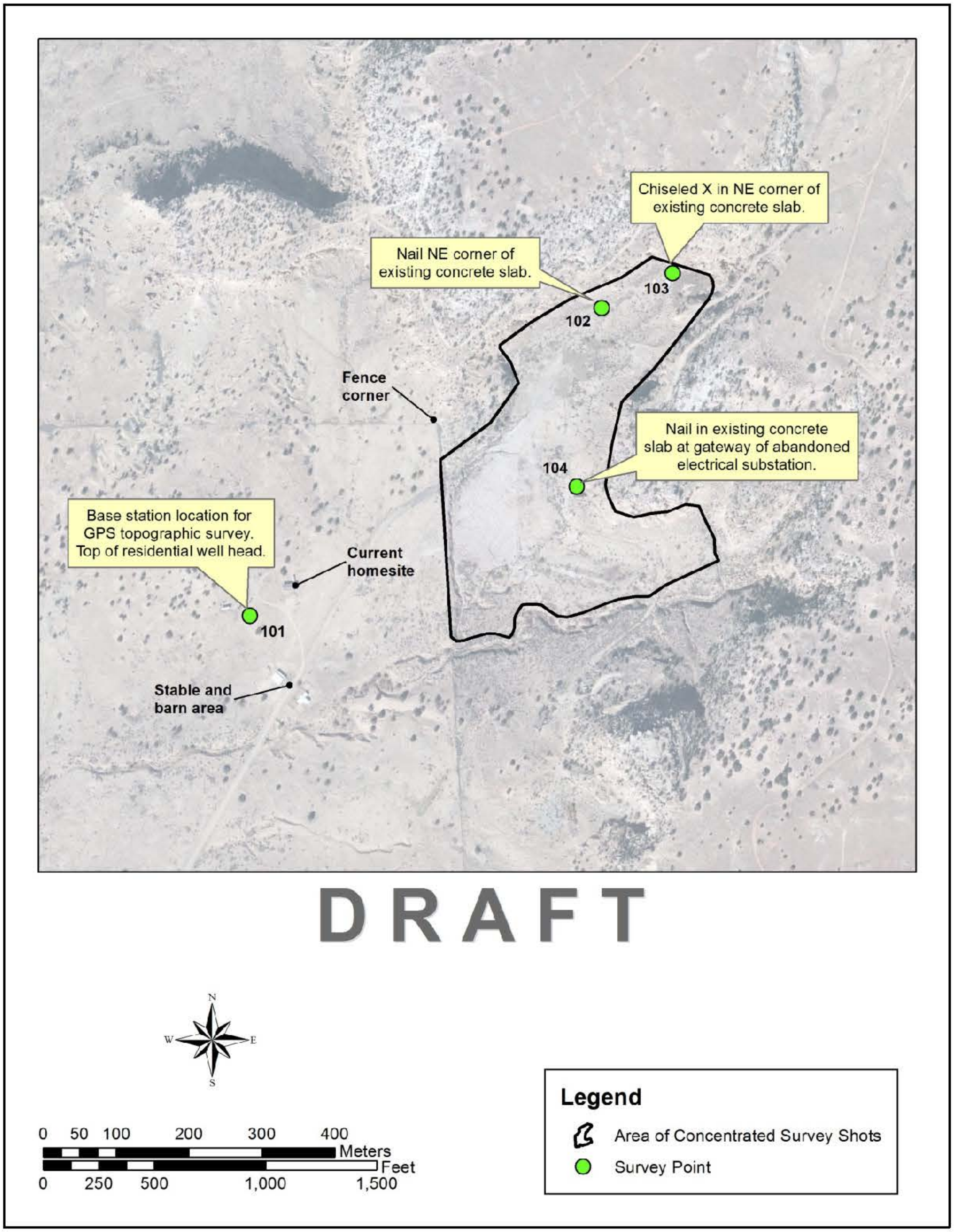



**Figure 4-1. Salient Ground Control and Survey Points**

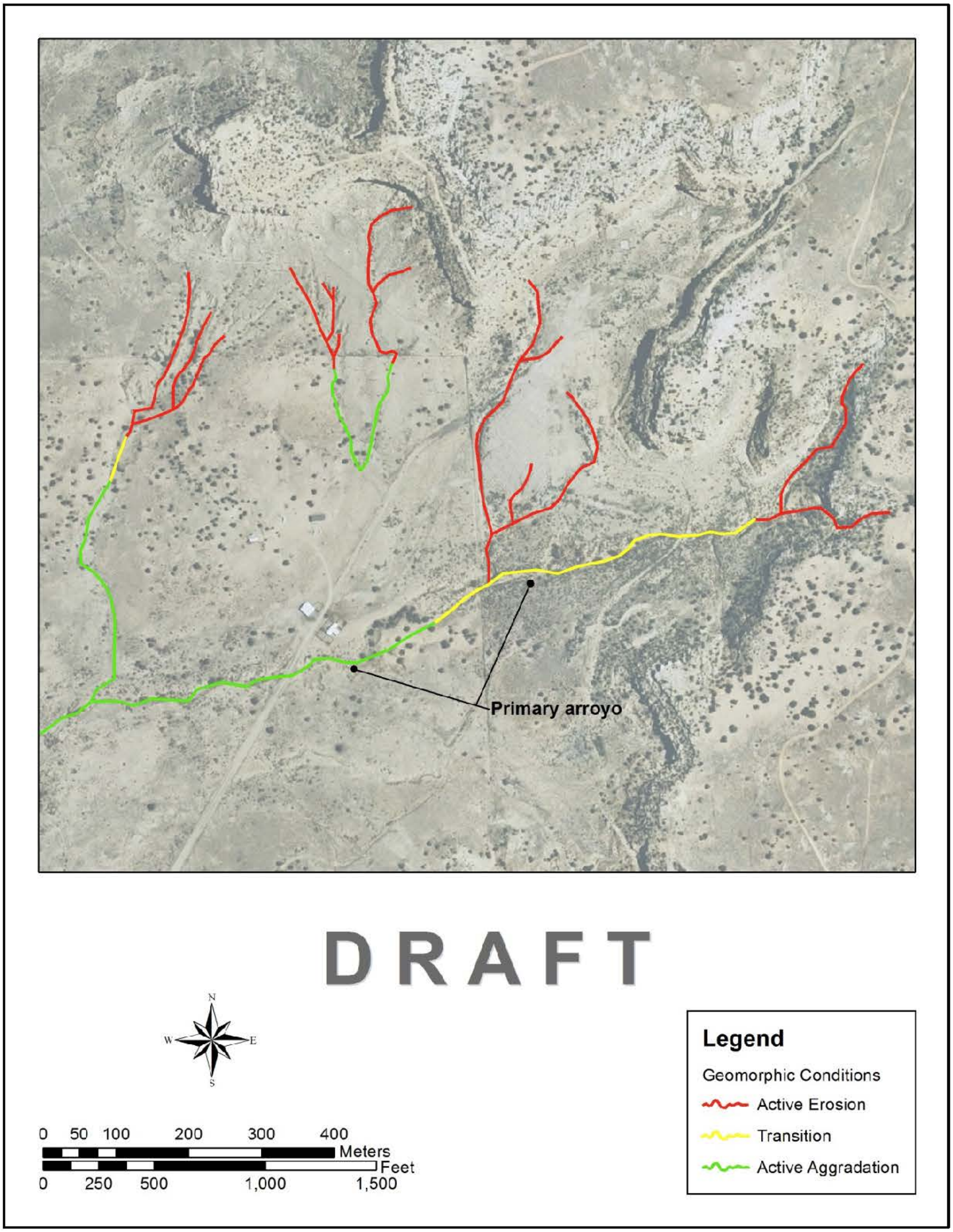



**Figure 4-2. Geomorphological Characterization of Arroyos in the Project Area**

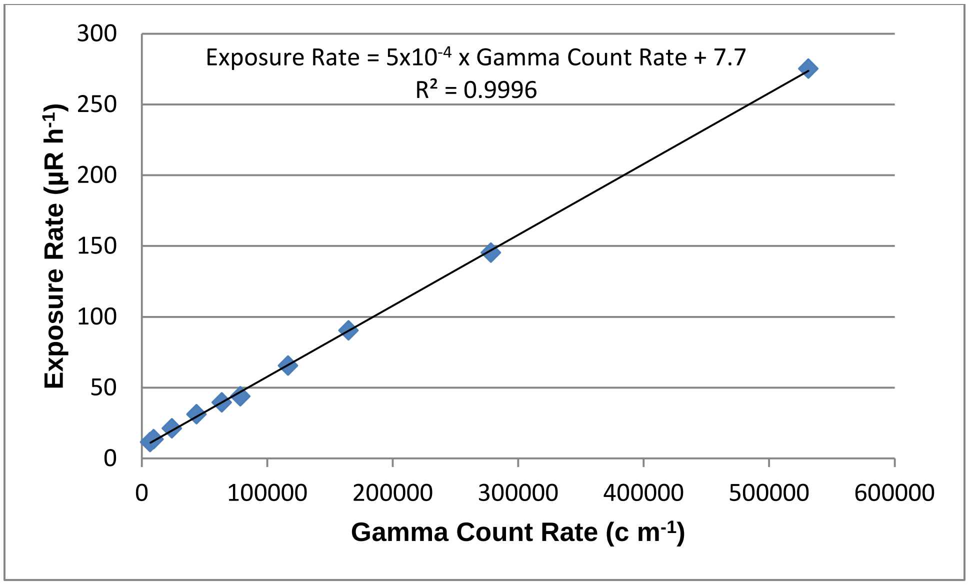



**Figure 4-3. Linear Regression of Exposure and Gamma Count Rates**

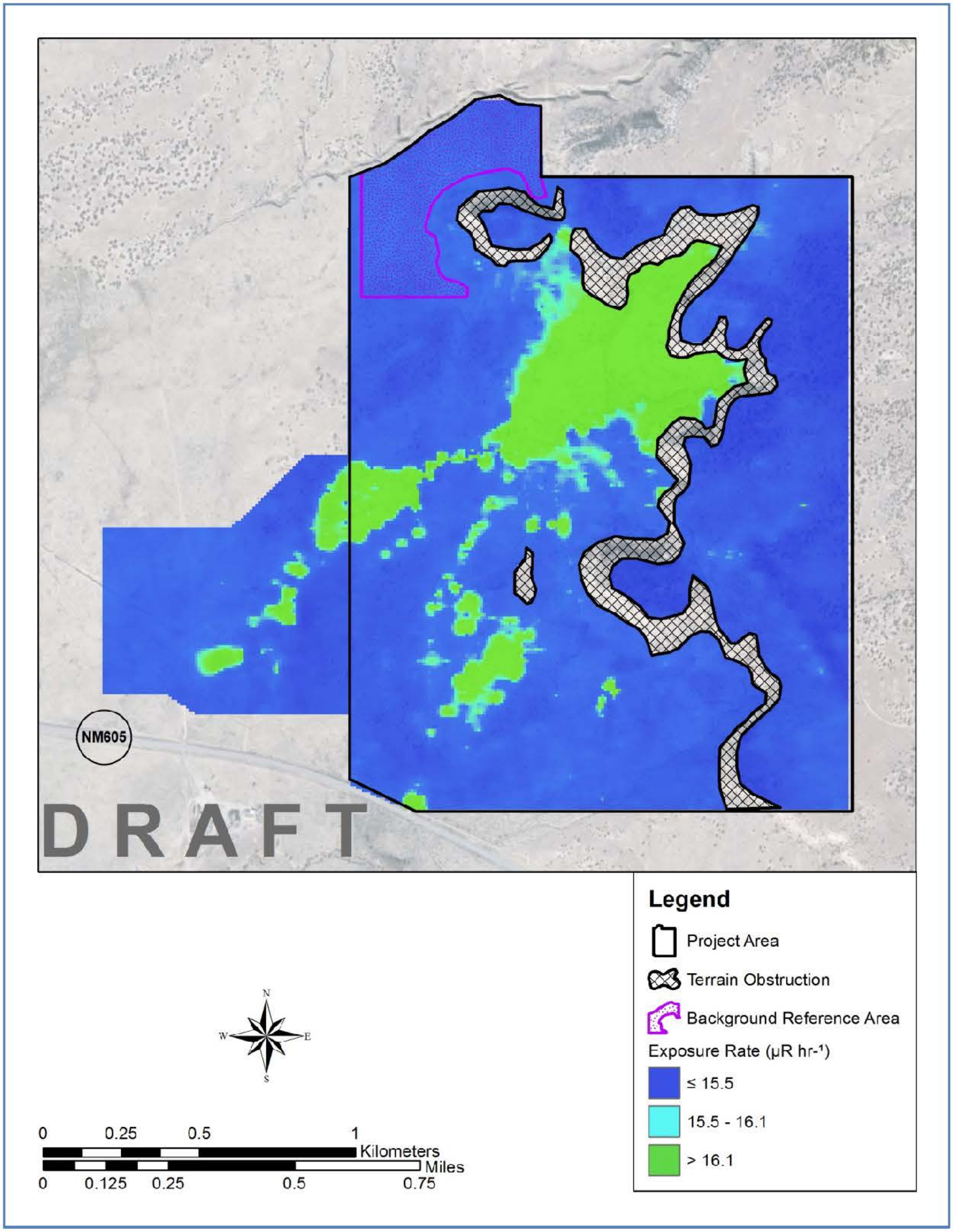



**Figure 4-4. Project Area-Wide Predicted Gamma Exposure Rates**

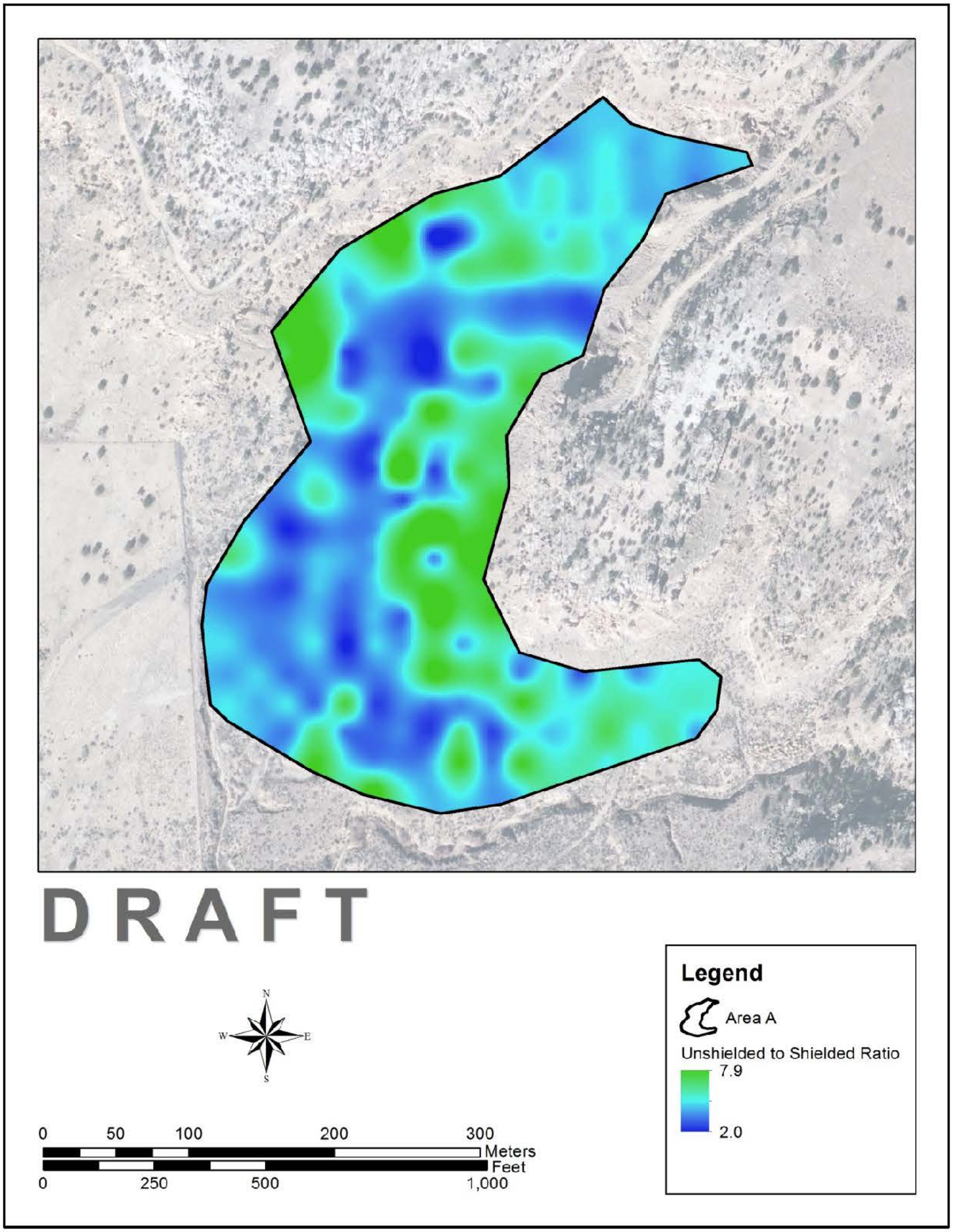
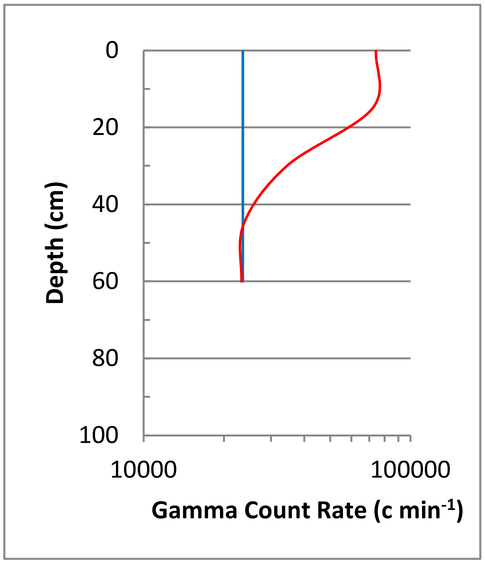
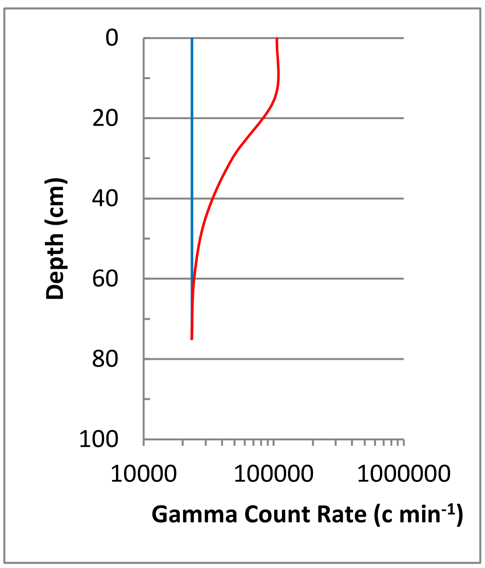


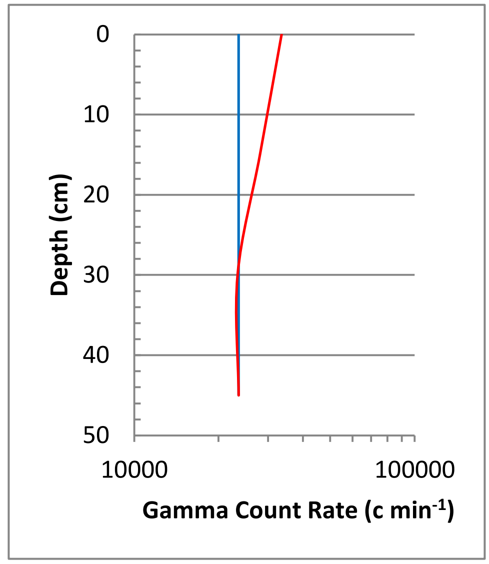

**Figure 4-5. Ratio of Unshielded to Shielded Measurements in Area A**



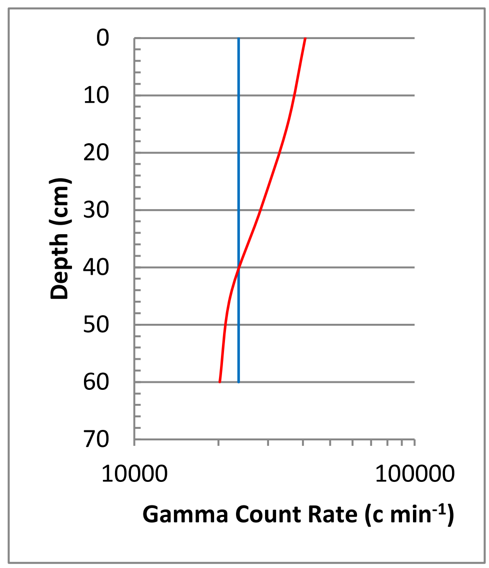

a. Location AC-01




b. Location AC-02



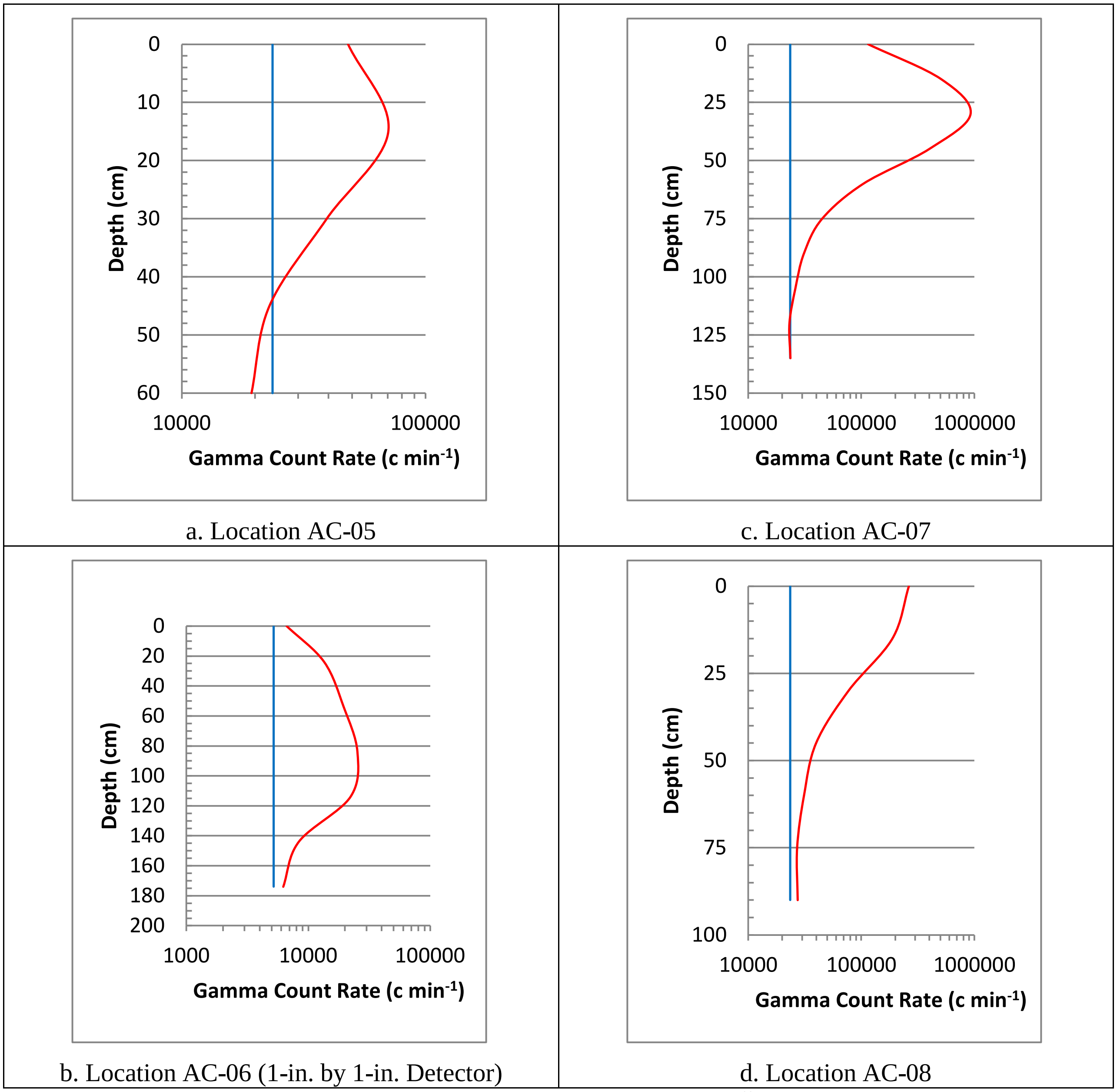

c. Location AC-03




d. Location AC-04

Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

**Figure 4-6. Down-hole Gamma Logs for Area C Borings (AC-01 through AC-04)**




a. Location AC-05

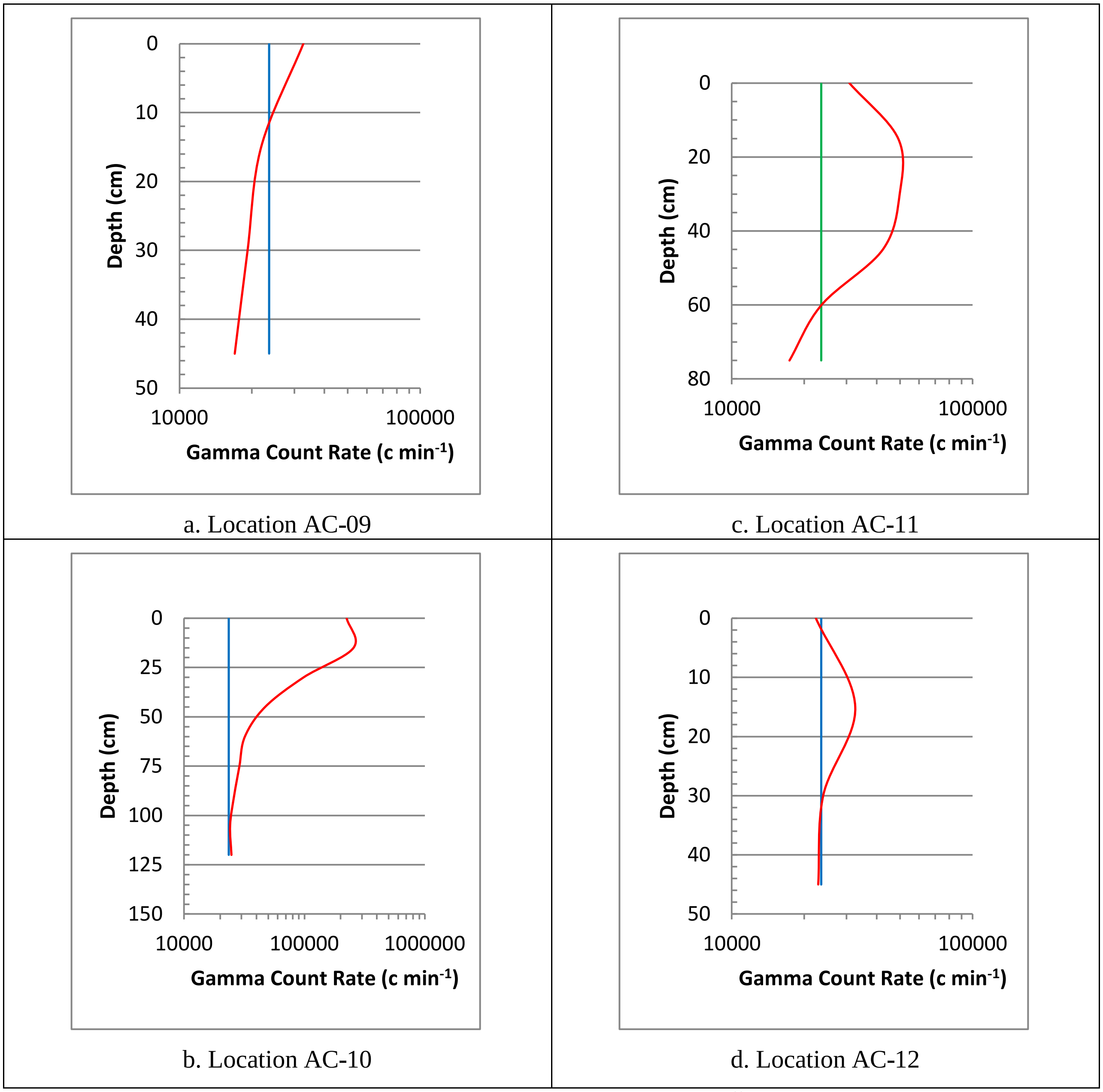
c. Location AC-07

b. Location AC-06 (1-in. by 1-in. Detector)

d. Location AC-08

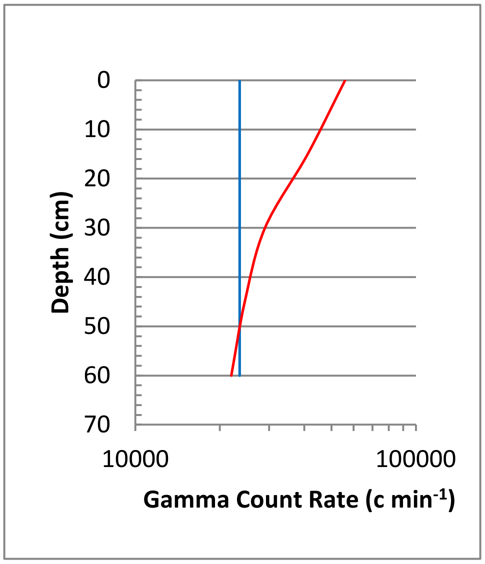
Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

**Figure 4-7. Down-hole Gamma Logs for Area C Borings (AC-05 through AC-08)**

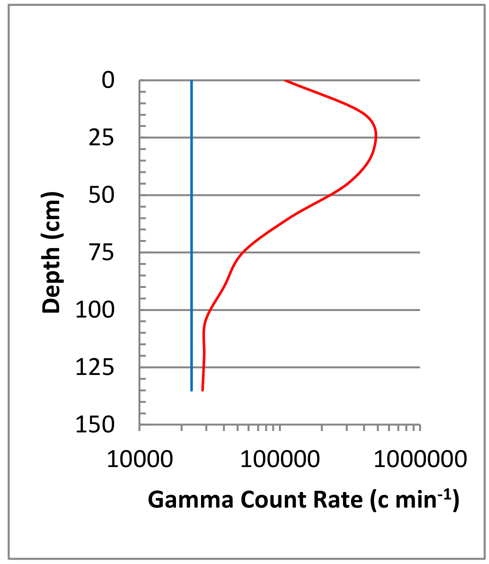



Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

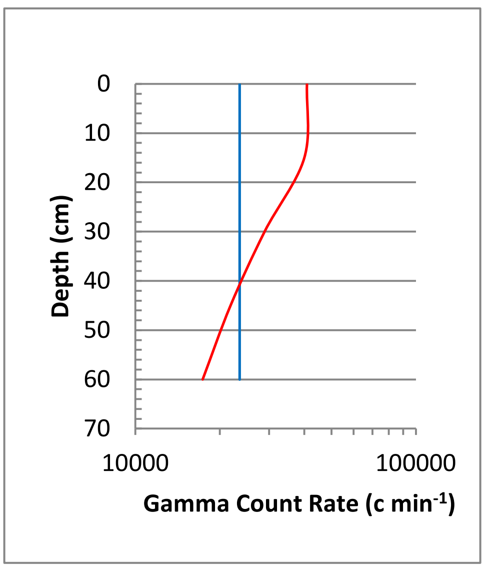
**Figure 4-8. Down-hole Gamma Logs for Area C Borings (AC-09 through AC-12)**



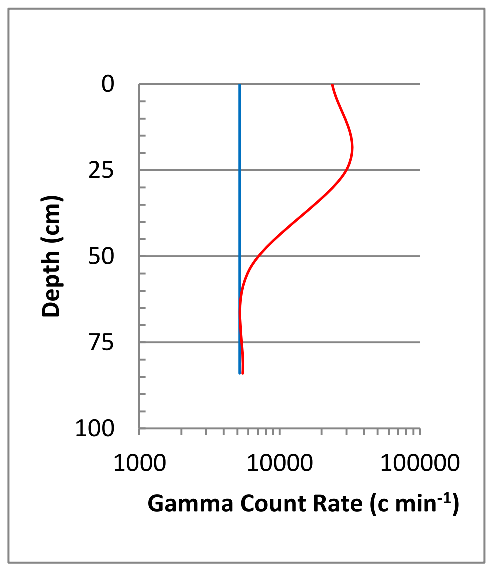

a. Location AC-13




c. Location AC-15



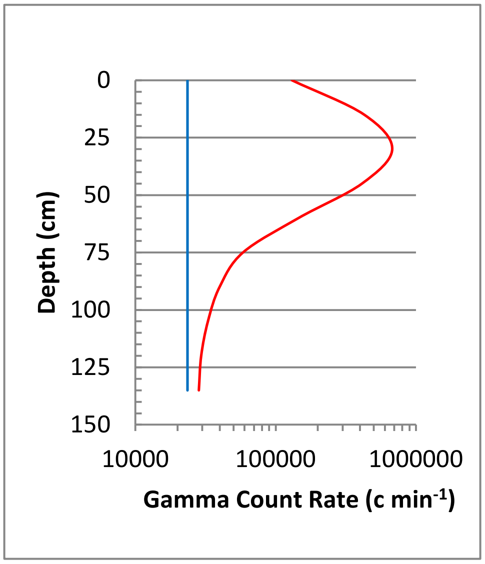

b. Location AC-14



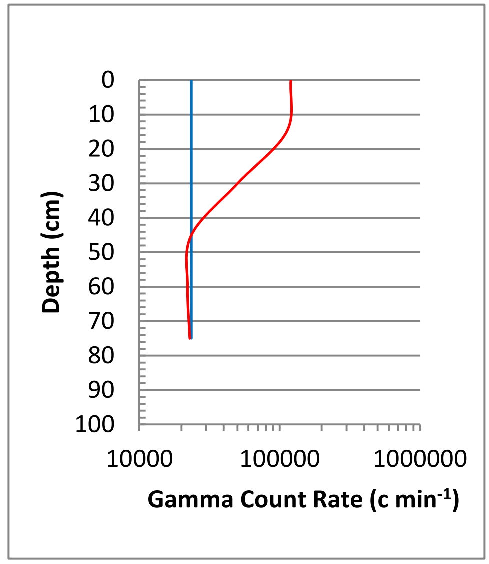

d. Location AC-16

Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

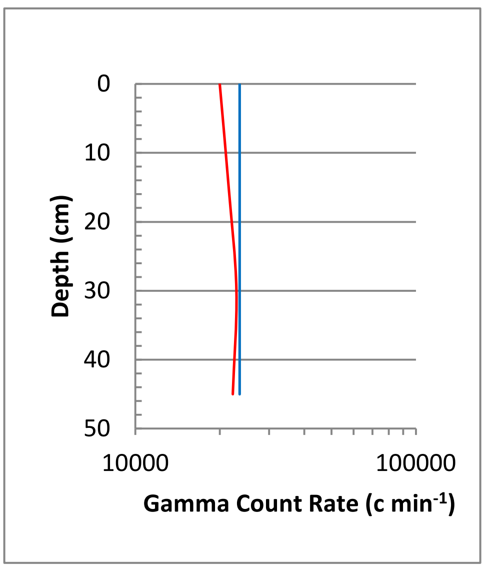
**Figure 4-9. Down-hole Gamma Logs for Area C Borings (AC-13 through AC-16)**



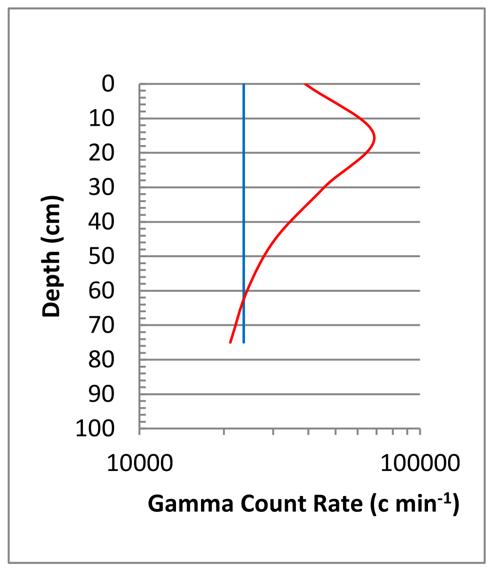

a. Location AC-17




c. Location AC-19



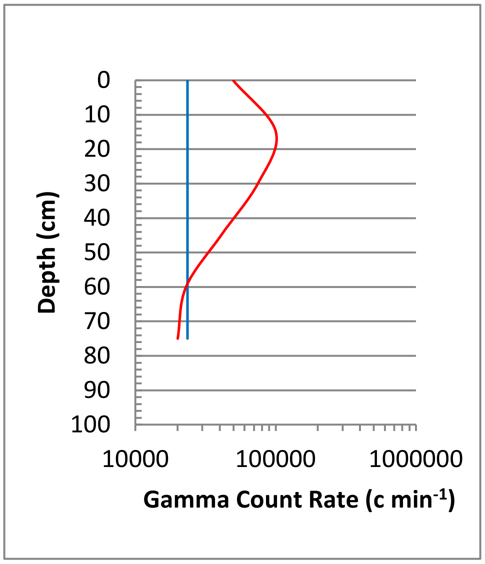

b. Location AC-18



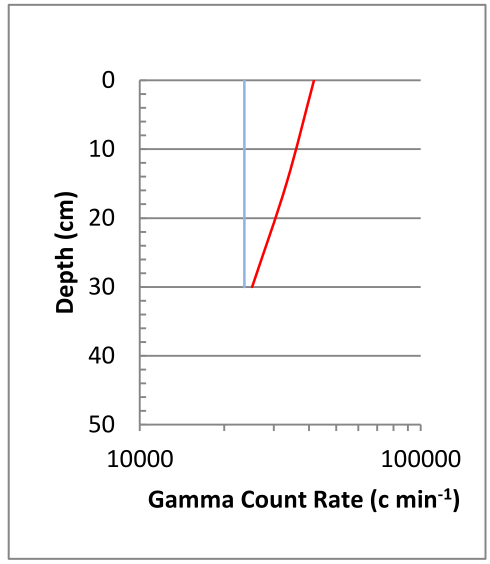

d. Location AC-20

Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

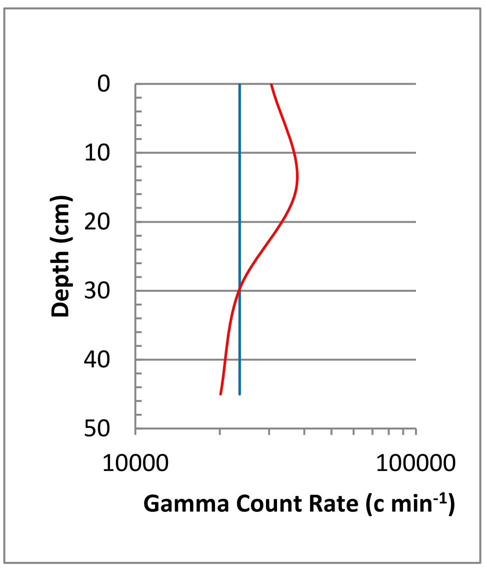
**Figure 4-10. Down-hole Gamma Logs for Area C Borings (AC-17 through AC-20)**




a. Location AC-21




c. Location AC-23




b. Location AC-22

Note: Red line depicts down-hole measurements. Blue (vertical) line indicates the respective cutoff value.

**Figure 4-11. Down-hole Gamma Logs for Area C Borings (AC-21 through AC-23)**

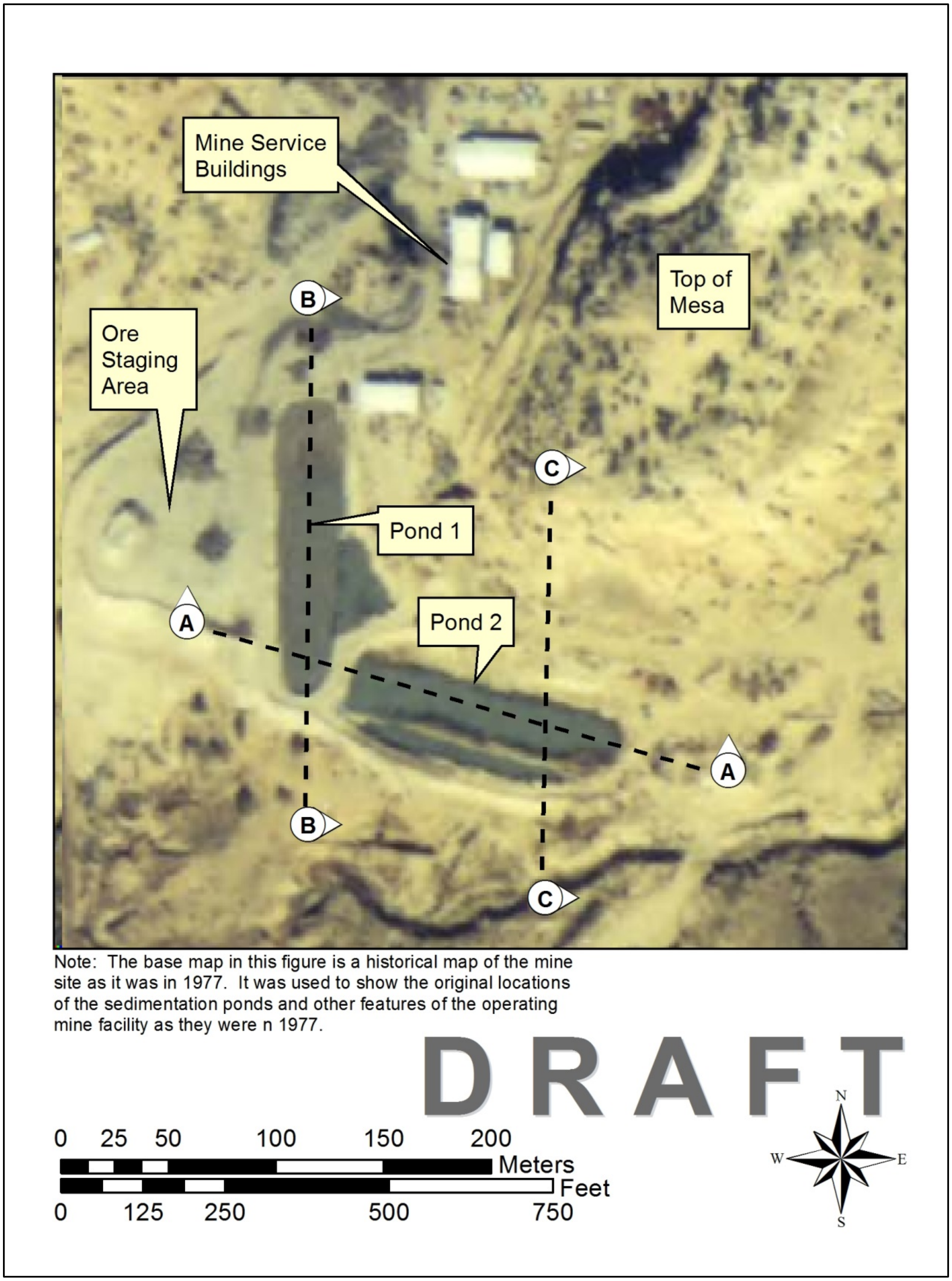



**Figure 4-12. Locations of Geotechnical Cross Sections**

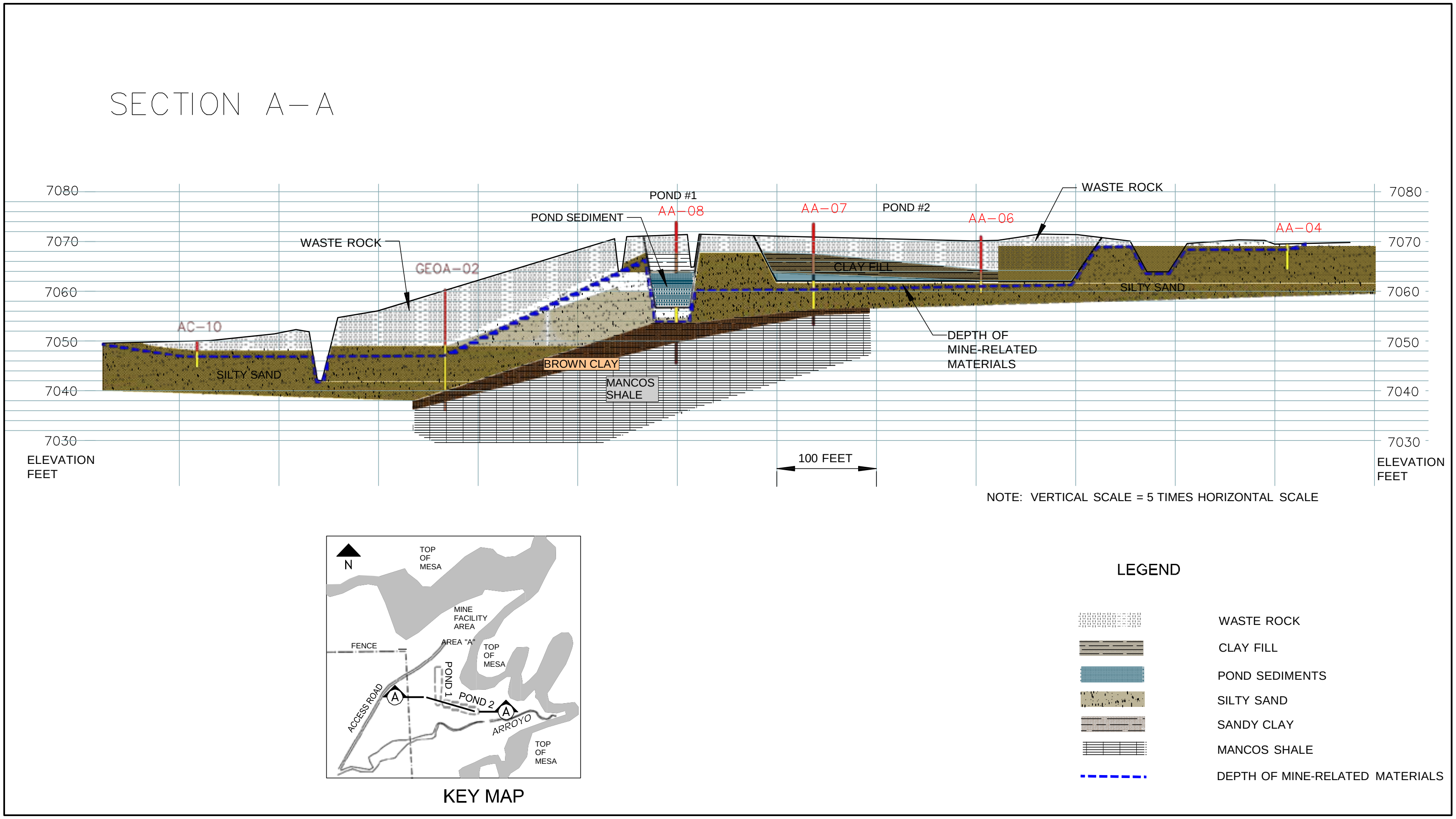



**Figure 4-13. Area A Geological Cross Section A – A'**

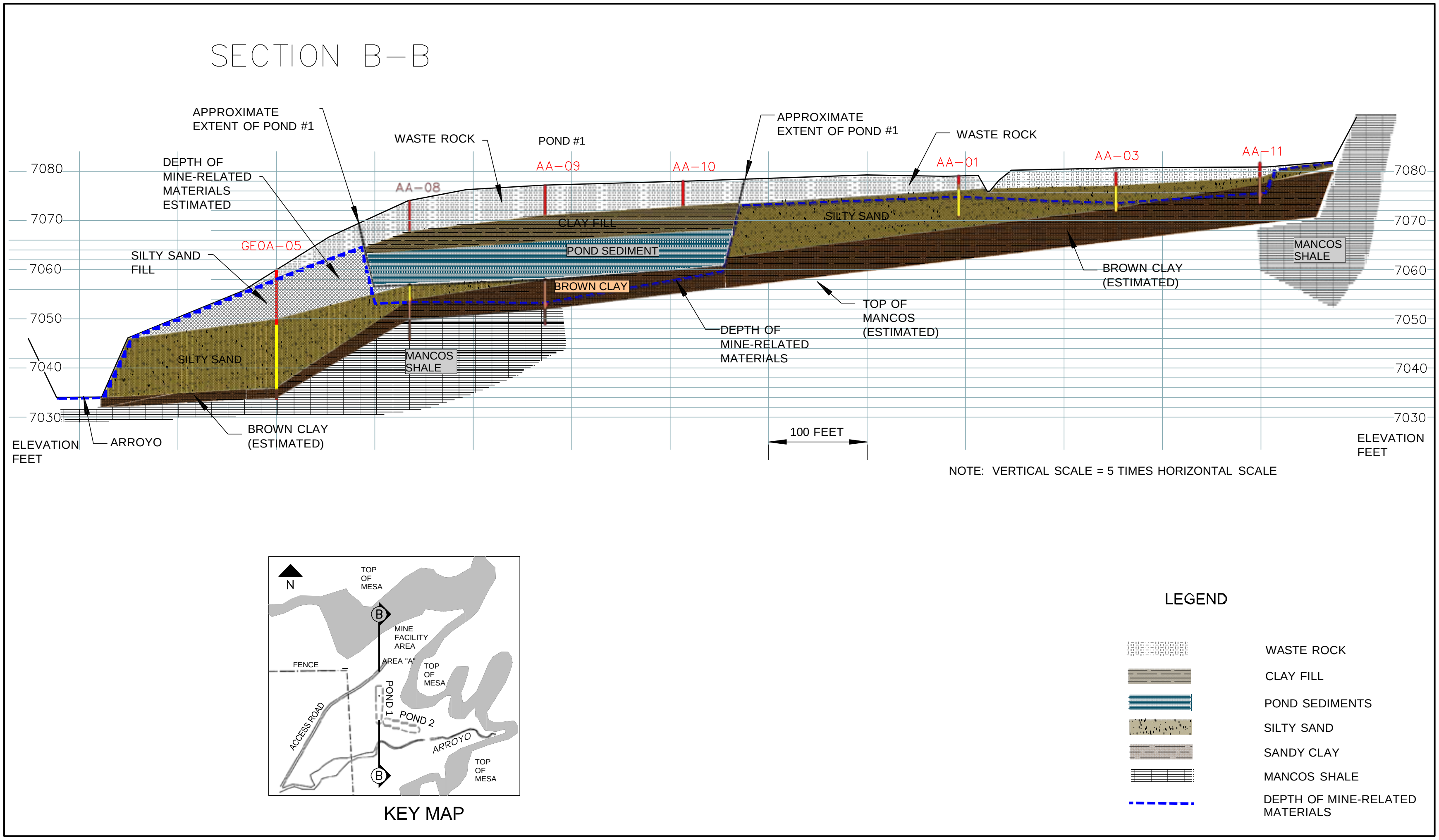



**Figure 4-14. Area A Geological Cross Section B – B'**

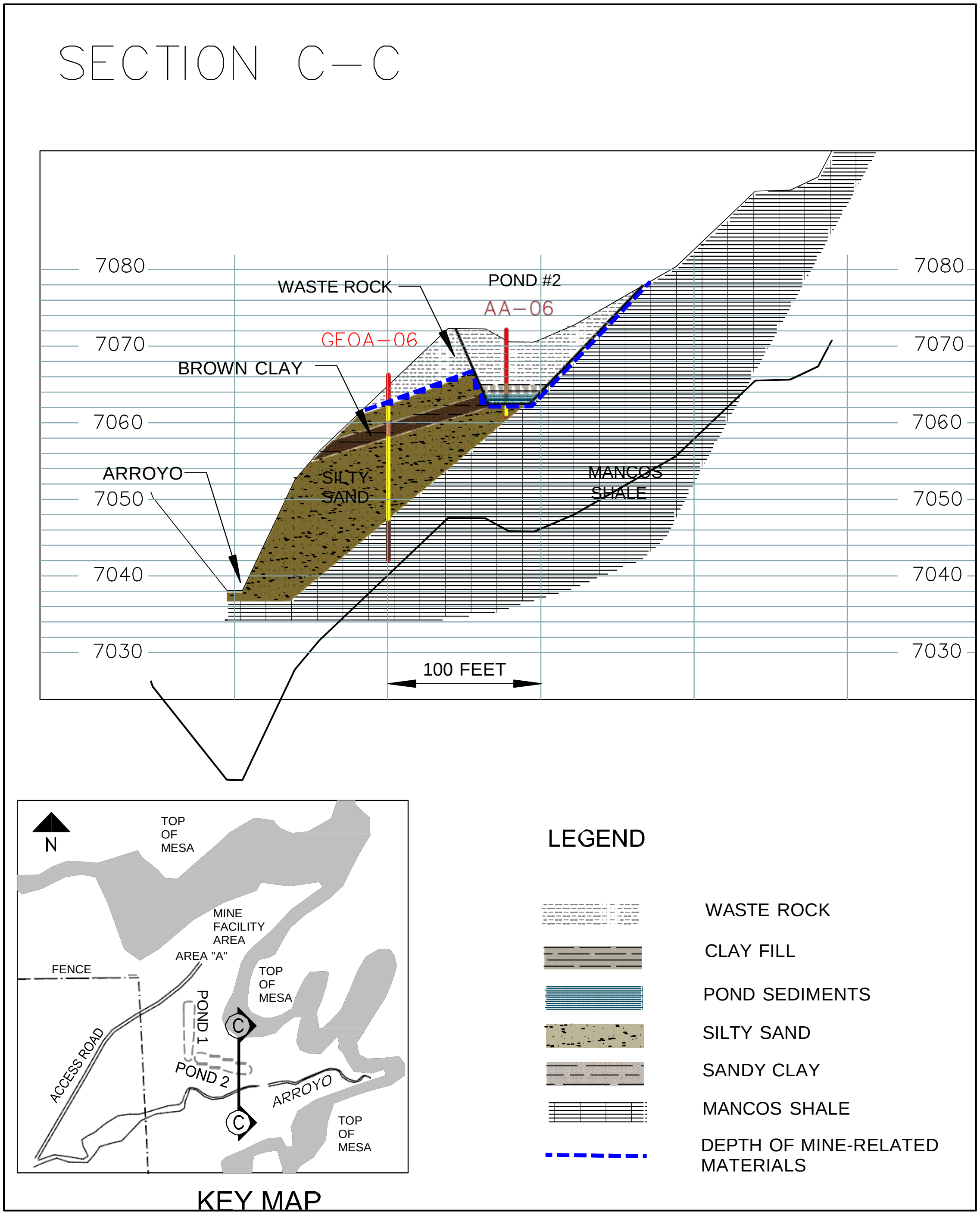



**Figure 4-15. Area A Geological Cross Section C – C'**

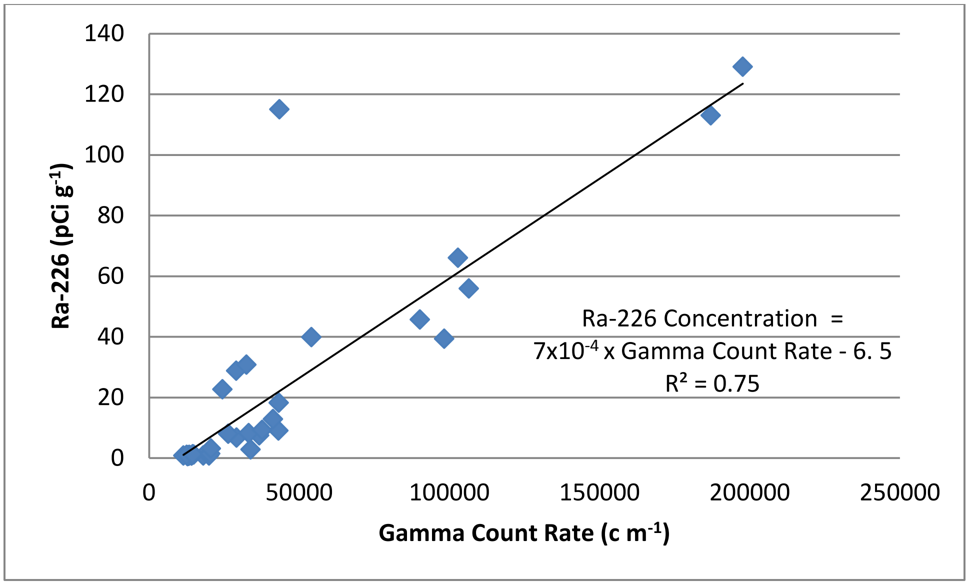



**Figure 4-16. Correlation of Radium-226 Concentrations and Gamma Count Rates**

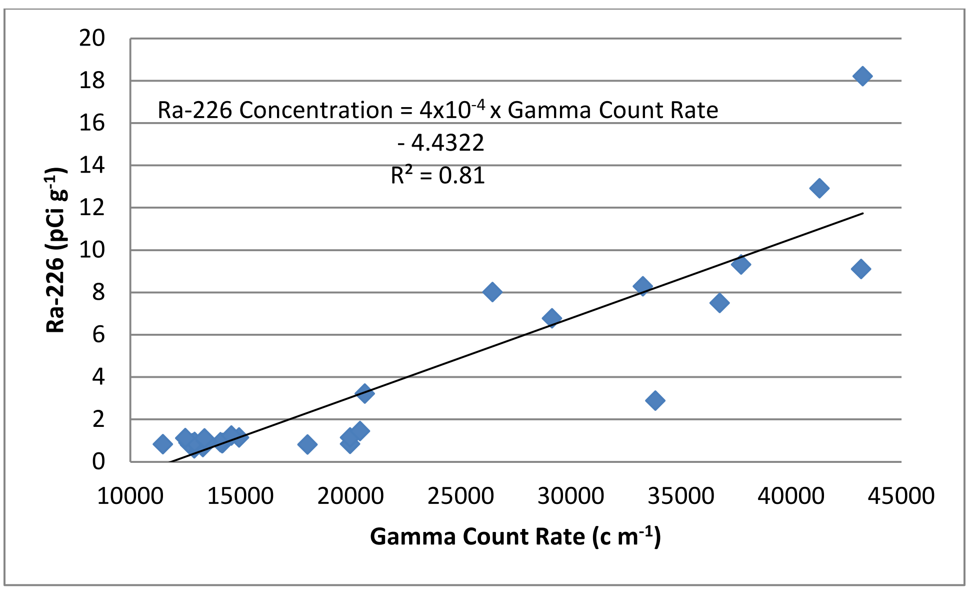



**Figure 4-17. Correlation of Radium-226 Concentrations and Gamma Count Rates: Limited Data Set**

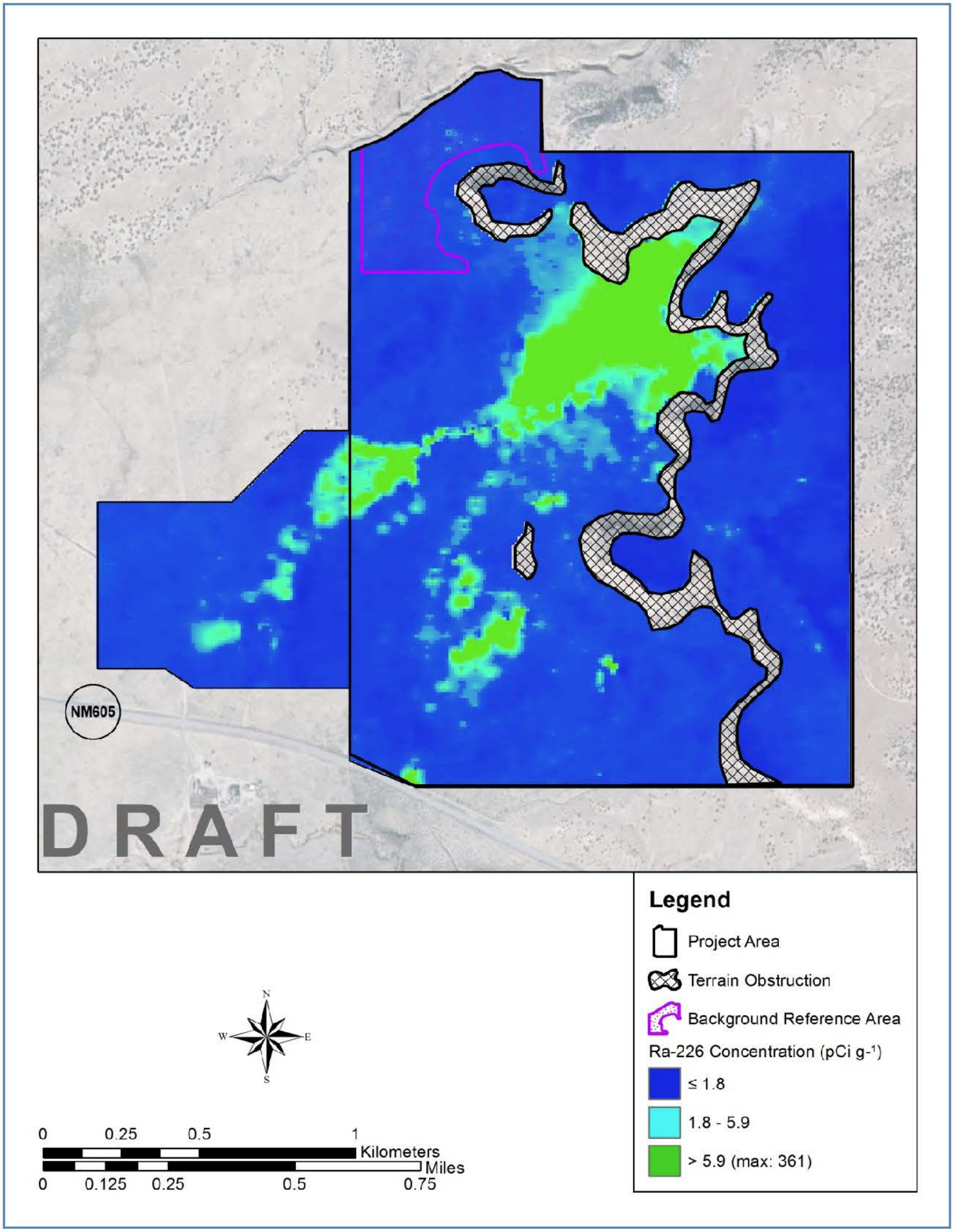



**Figure 4-18. Radium-226 Concentrations Predicted from Gamma Count Rates**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-01-0015-101512 | 0-15 | 10 | 540 | 21 | 13 | 40 | 290 |
| AA-01-15115-10152 | 15-115 | 4.6 | 460 | 13 | 0.97 | 1.5 | 52 |
| AA-01-115145-101512 | 115-145 | 3.3 | 400 | 9.9 | 2.4 | 0.26 | 11 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

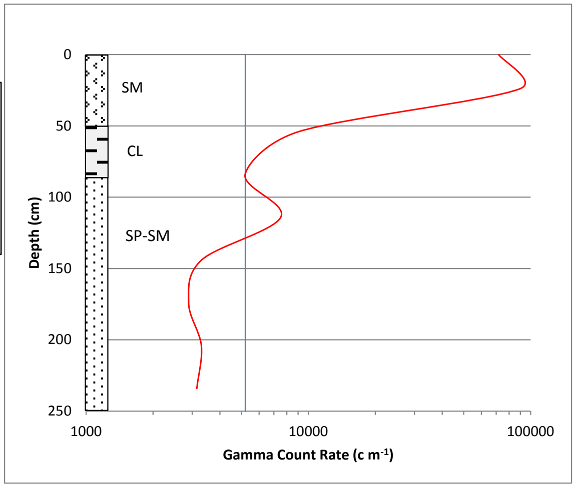
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-01-0015-101512 | 0-15 | 129 | 15 | 76 | 12 | 327 |
| AA-01-15115-10152 | 15-115 | 3.17 | 0.38 | 2.02 | 0.35 | 8 |
| AA-01-115145-101512 | 115-145 | 1.23 | 0.17 | 0.49 | 0.12 | 0.8 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SM = waste rock
SP = poor graded sand
CL = clay

Vertical line is cutoff value



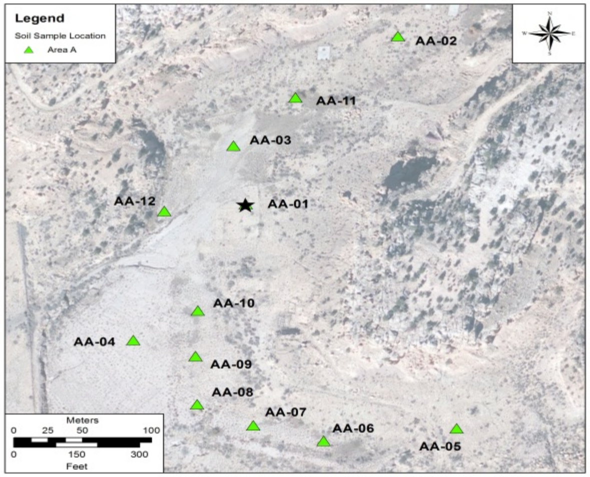




**Figure 4-19. Down-hole Logging and Soil Sample Results: Sample Location AA-01**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg $kg^{-1}$) | Barium (mg $kg^{-1}$) | Lead (mg $kg^{-1}$) | Molybdenum (mg $kg^{-1}$) | Selenium (mg $kg^{-1}$) | Vanadium (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-02-SS-0015-101112 | 0-15 | 10 | 390 | 16 | 0.88 | 0.65 | 0.1 |
| AA-02-SS-1530-101112 | 15-30 | 13 | 450 | 18 | 0.93 | 0.84 | 0.098 |

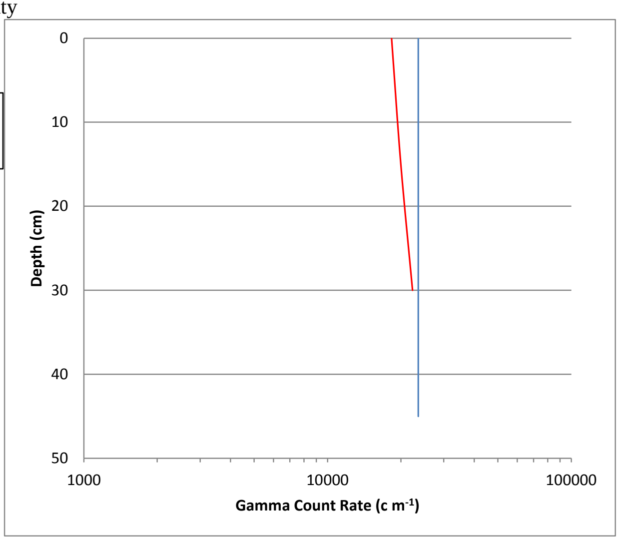
cm = centimeters
mg $kg^{-1}$ = milligrams per kilogram

## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi $g^{-1}$ | TPU | pCi $g^{-1}$ | TPU | pCi $g^{-1}$ |
| AA-02-SS-0015-101112 | 0-15 | 1.13 | 0.14 | 1.27 | 0.23 | 1.8 |
| AA-02-SS-1530-101112 | 15-30 | 1.06 | 0.14 | 1.04 | 0.21 | 1.7 |

cm = centimeters
mg $kg^{-1}$ = milligrams per kilogram
pCi $g^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

Vertical line is cutoff value



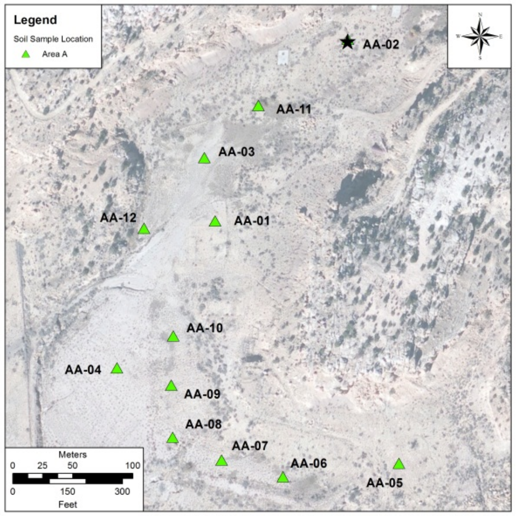




**Figure 4-20. Down-hole Logging and Soil Sample Results: Boring AA-02**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-03-SS-0015-101512 | 0-15 | 6.7 | 450 | 14 | 6.8 | 28 | 190 |
| AA-03-SS-15145-101512 | 15-145 | 20 | 620 | 21 | 36 | 57 | 240 |
| AA-03-SS-145235-101512 | 145-235 | 6.5 | 500 | 13 | 1 | 1 | 37 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

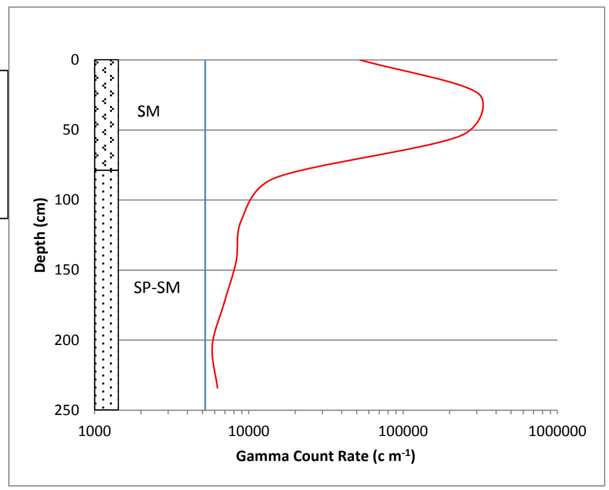
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-03-SS-0015-101512 | 0-15 | 244 | 29 | 282 | 44 | 308 |
| AA-03-SS-15145-101512 | 15-145 | 129 | 15 | 126 | 20 | 266 |
| AA-03-SS-145235-101512 | 145-235 | 1.66 | 0.21 | 0.94 | 0.18 | 4.1 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SM = waste rock
SP = poor graded sand

Vertical line is cutoff value



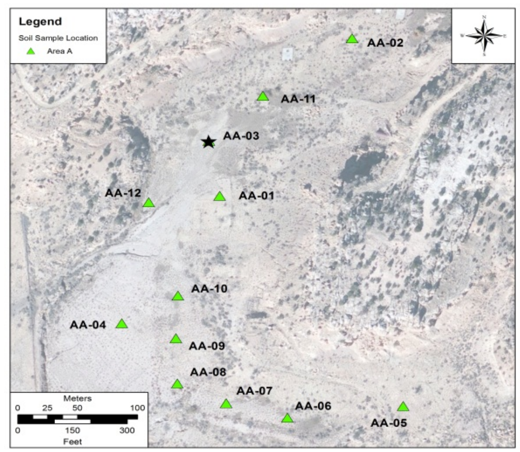




**Figure 4-21. Down-hole Logging and Soil Sample Results: Boring AA-03**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-04-SS-0015-102212 | 0-15 | 12 | 360 | 17 | 56 | 20 | 120 |
| AA-04-SS-15205-102212 | 15-205 | 1.9 | 450 | 15 | 1.2 | 1.6 | 47 |
| AA-04-SS-205300-102212 | 205-300 | 10 | 350 | 21 | 1.2 | 0.89 | 64 |

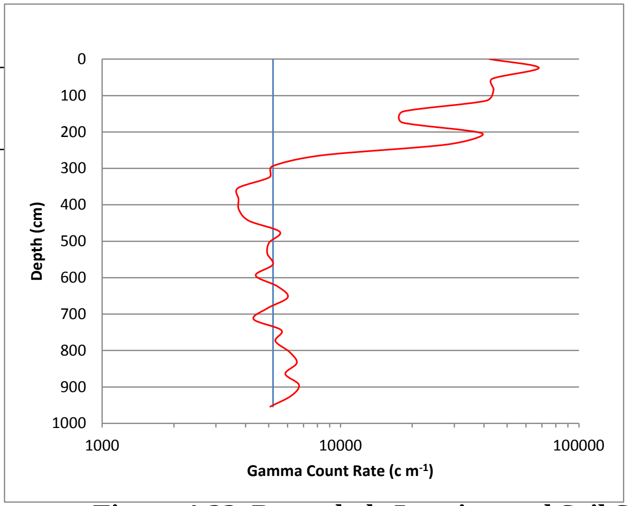
cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-04-SS-0015-102212 | 0-15 | 112 | 13 | 120 | 19 | 378 |
| AA-04-SS-15205-102212 | 15-205 | 20.6 | 2.4 | 11.2 | 1.7 | 8 |
| AA-04-SS-205300-102212 | 205-300 | 2.07 | 0.26 | 1.15 | 0.22 | 2.3 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

Vertical line is cutoff value



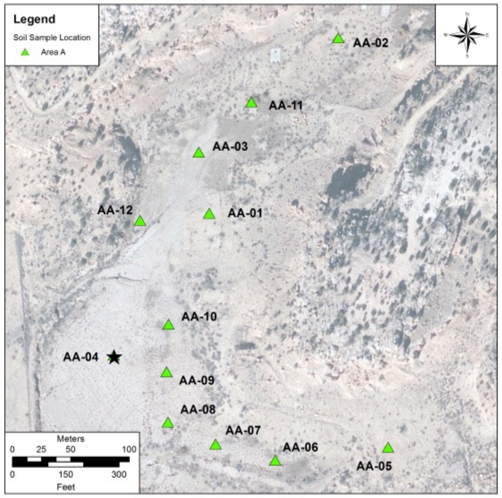




**Figure 4-22. Down-hole Logging and Soil Sample Results: Boring AA-04**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-05-SS-0015-102212 | 0-15 | 3.7 | 430 | 11 | 1.1 | 1.1 | 29 |
| AA-05-SS-15230-101612 | 15-230 | 2.3 | 360 | 7.5 | 0.8 | 0.2 | 14 |

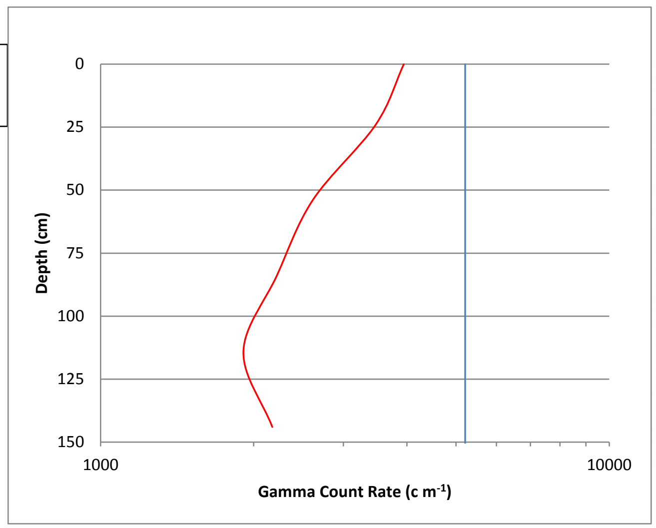
cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-05-SS-0015-102212 | 0-15 | 2.43 | 0.3 | 2.32 | 0.39 | 1.8 |
| AA-05-SS-15230-101612 | 15-230 | 0.395 | 0.065 | 0.43 | 0.1 | 0.9 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

Vertical line is cutoff value



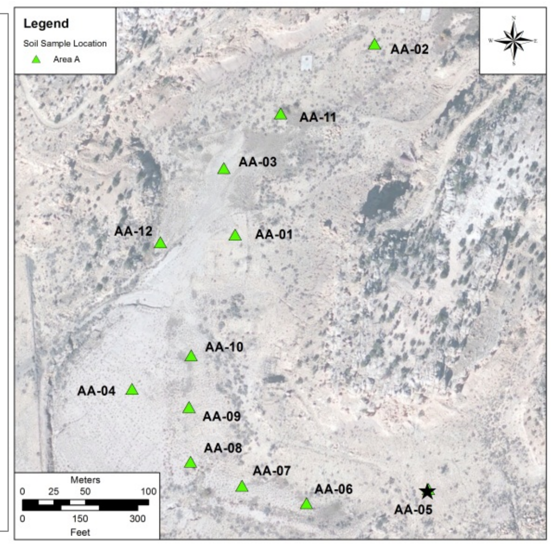




**Figure 4-23. Down-hole Logging and Soil Sample Results: Boring AA-05**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-06-SS-0015-101512 | 0-15 | 5 | 790 | 14 | 4.2 | 10 | 110 |
| AA-06-SS-15355-101512 | 15-355 | 3.8 | 410 | 13 | 5 | 3.2 | 36 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

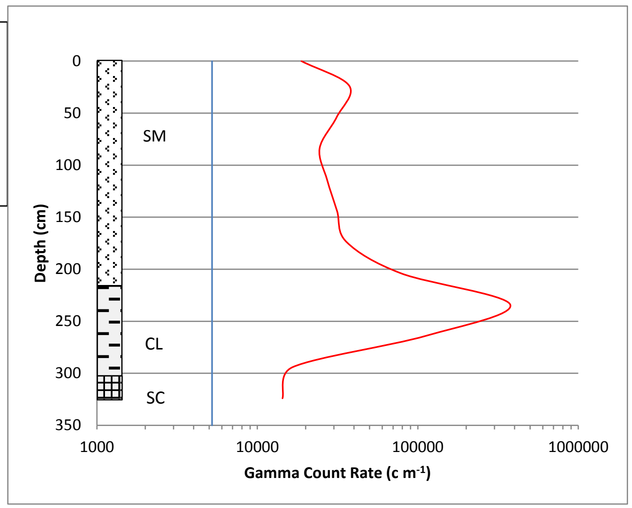
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-06-SS-0015-101512 | 0-15 | 63.1 | 7.4 | 35.3 | 5.5 | 37 |
| AA-06-SS-15355-101512 | 15-355 | 15.1 | 1.8 | 50 | 8.5 | 29 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SM = waste rock
CL = clay
SC = clayey sand

Vertical line is cutoff value



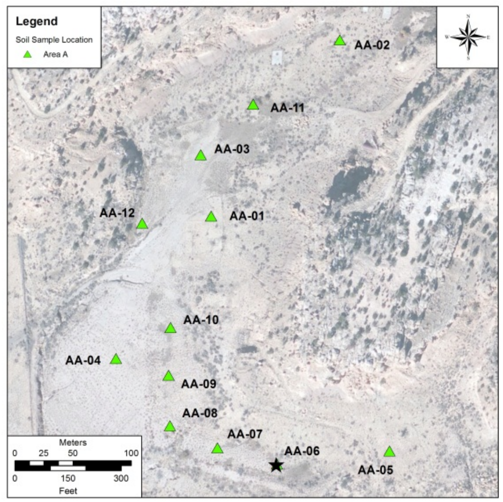




**Figure 4-24. Down-hole Logging and Soil Sample Results: Boring AA-06**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-07-SS-0015-101612 | 0-15 | 7.4 | 540 | 16 | 7.7 | 21 | 120 |
| AA-07-SS-15415-101612 | 15-415 | 10 | 600 | 20 | 14 | 39 | 190 |
| AA-07-SS-415505-101612 | 415-505 | 9.4 | 530 | 16 | 2.3 | 0.93 | 61 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

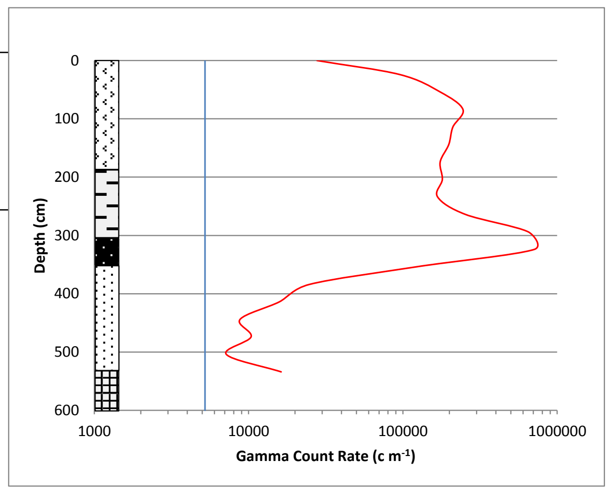
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-07-SS-0015-101612 | 0-15 | 77.7 | 9.1 | 63.1 | 9.8 | 182 |
| AA-07-SS-15415-101612 | 15-415 | 255 | 30 | 405 | 63 | 273 |
| AA-07-SS-415505-101612 | 415-505 | 1.4 | 0.18 | 1.31 | 0.23 | 13 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SM = waste rock
CL = clay
OH = organic clay

Vertical line is cutoff value



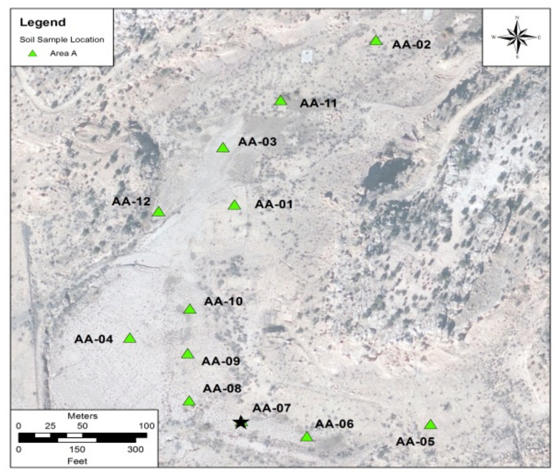




**Figure 4-25. Down-hole Logging and Soil Sample Results: Boring AA-07**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic ($mg\ kg^{-1}$) | Barium ($mg\ kg^{-1}$) | Lead ($mg\ kg^{-1}$) | Molybdenum ($mg\ kg^{-1}$) | Selenium ($mg\ kg^{-1}$) | Vanadium ($mg\ kg^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-08-SS-0015-101612 | 0-15 | 7 | 500 | 15 | 3 | 15 | 140 |
| AA-08-SS-15565-101612 | 15-565 | 5.4 | 480 | 14 | 7.3 | 16 | 130 |
| AA-08-SS-565795-101612 | 565-795 | 15 | 170 | 23 | 1.8 | 0.59 | 82 |

cm = centimeters
$mg\ kg^{-1}$ = milligrams per kilogram

## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | $pCi\ g^{-1}$ | TPU | $pCi\ g^{-1}$ | TPU | $pCi\ g^{-1}$ |
| AA-08-SS-0015-101612 | 0-15 | 58.3 | 6.8 | 44.9 | 6.9 | 38 |
| AA-08-SS-15565-101612 | 15-565 | 71.9 | 8.4 | 44.2 | 6.9 | 50 |
| AA-08-SS-565795-101612 | 565-795 | 2.14 | 0.26 | 1.9 | 0.33 | 2.4 |

cm = centimeters
$mg\ kg^{-1}$ = milligrams per kilogram
$pCi\ g^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

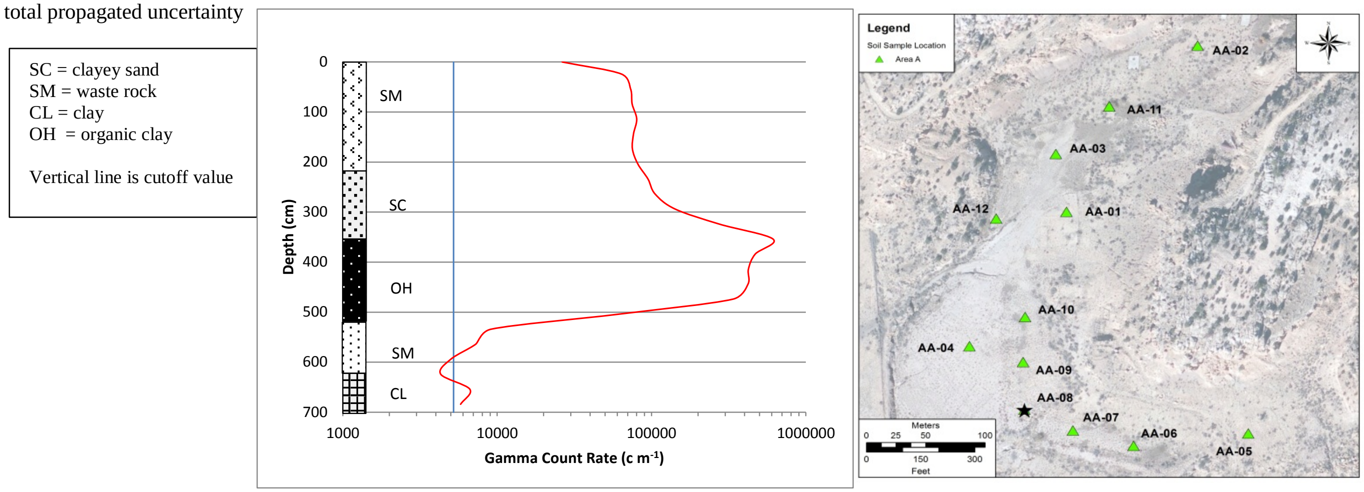



**Figure 4-26. Down-hole Logging and Soil Sample Results: Boring AA-08**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic ($mg\ kg^{-1}$) | Barium ($mg\ kg^{-1}$) | Lead ($mg\ kg^{-1}$) | Molybdenum ($mg\ kg^{-1}$) | Selenium ($mg\ kg^{-1}$) | Vanadium ($mg\ kg^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-09-SS-0015-101612 | 0-15 | 8.6 | 540 | 18 | 6.6 | 67 | 230 |
| AA-09-SS-15750-101612 | 15-750 | 9 | 490 | 19 | 13 | 43 | 270 |
| AA-09-SS-750950-101612 | 750-950 | 12 | 560 | 21 | 2.4 | 0.77 | 88 |

cm = centimeters
$mg\ kg^{-1}$ = milligrams per kilogram

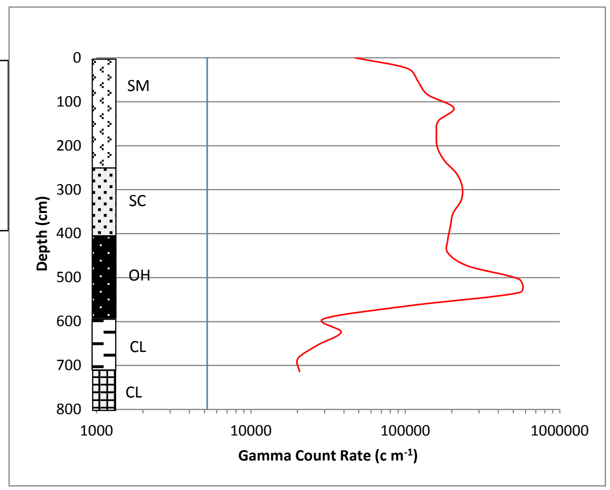
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | $pCi\ g^{-1}$ | TPU | $pCi\ g^{-1}$ | TPU | $pCi\ g^{-1}$ |
| AA-09-SS-0015-101612 | 0-15 | 108 | 13 | 96 | 15 | 98 |
| AA-09-SS-15750-101612 | 15-750 | 120 | 14 | 110 | 17 | 133 |
| AA-09-SS-750950-101612 | 750-950 | 2.82 | 0.35 | 3.88 | 0.64 | 3 |

cm = centimeters
$mg\ kg^{-1}$ = milligrams per kilogram
$pCi\ g^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SC = clayey sand
SM = waste rock
CL = clay
OH = organic clay

Vertical line is cutoff value



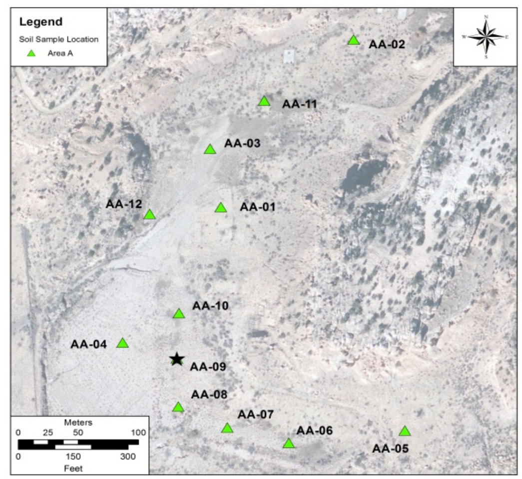




**Figure 4-27. Down-hole Logging and Soil Sample Results: Boring AA-09**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-10-SS-0015-101512 | 0-15 | 9.1 | 410 | 19 | 15 | 68 | 150 |
| AA-10-SS-15415-101512 | 15-145 | 7.6 | 230 | 13 | 2.4 | 4.1 | 37 |
| AA-10-SS-415525-101512 | 145-525 | 5.4 | 440 | 16 | 1.3 | 0.6 | 45 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

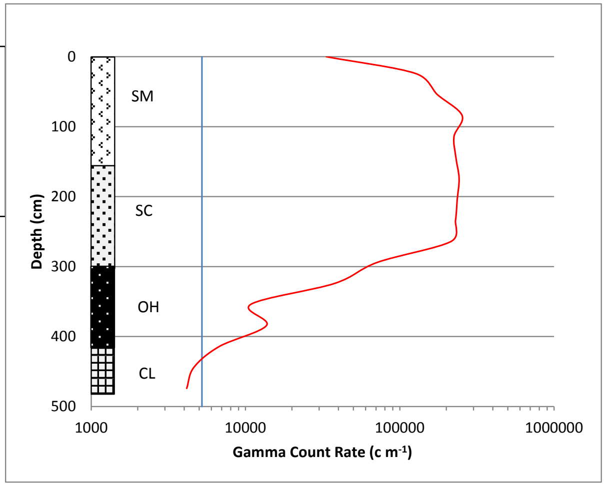
## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-10-SS-0015-101512 | 0-15 | 134 | 16 | 124 | 19 | 231 |
| AA-10-SS-15415-101512 | 15-145 | 130 | 15 | 104 | 16 | 60 |
| AA-10-SS-415525-101512 | 145-525 | 0.88 | 0.12 | 0.76 | 0.15 | 1.6 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SC = clayey sand
SM = waste rock
CL = clay
OH = organic clay

Vertical line is cutoff value



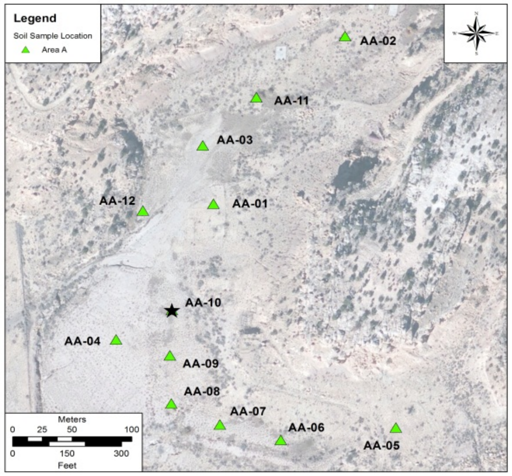




**Figure 4-28. Down-hole Logging and Soil Sample Results: Boring AA-10**

## Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-11-SS-0015-101512 | 0-15 | 6 | 240 | 13 | 5.3 | 5.1 | 69 |
| AA-11-SS-15145-101512 | 15-145 | 7.1 | 360 | 14 | 4.4 | 8.5 | 95 |
| AA-11-SS-145245-101512 | 145-245 | 4 | 420 | 11 | 0.68 | 0.81 | 30 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

## Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-11-SS-0015-101512 | 0-15 | 47.3 | 5.5 | 463 | 72 | 66 |
| AA-11-SS-15145-101512 | 15-145 | 33.2 | 3.9 | 37 | 5.8 | 84 |
| AA-11-SS-145245-101512 | 145-245 | 0.84 | 0.11 | 0.75 | 0.15 | 1.9 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SC = clayey sand
SM = waste rock

Vertical line is cutoff value

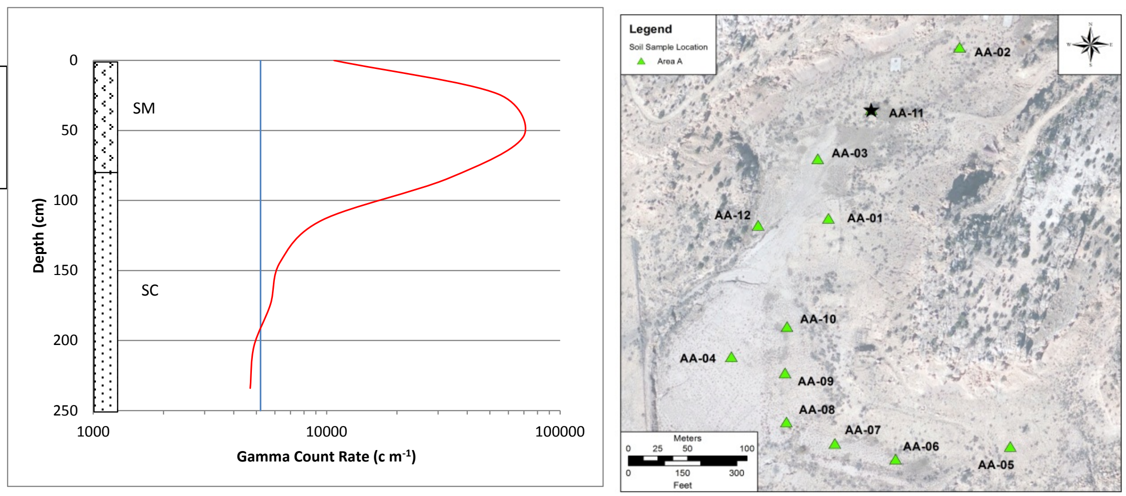



**Figure 4-29. Down-hole Logging and Soil Sample Results: Boring AA-11**

### Metals Results in Soil Samples

| Sample ID | Depth (cm) | Arsenic (mg kg$^{-1}$) | Barium (mg kg$^{-1}$) | Lead (mg kg$^{-1}$) | Molybdenum (mg kg$^{-1}$) | Selenium (mg kg$^{-1}$) | Vanadium (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|
| AA-12-SS-0015-101512 | 0-15 | 12 | 560 | 21 | 16 | 33 | 240 |
| AA-12-SS-15115-101512 | 15-115 | 16 | 390 | 22 | 6.2 | 13 | 100 |
| AA-12-SS-115245-101512 | 115-245 | 5 | 460 | 12 | 1.7 | 5.1 | 43 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram

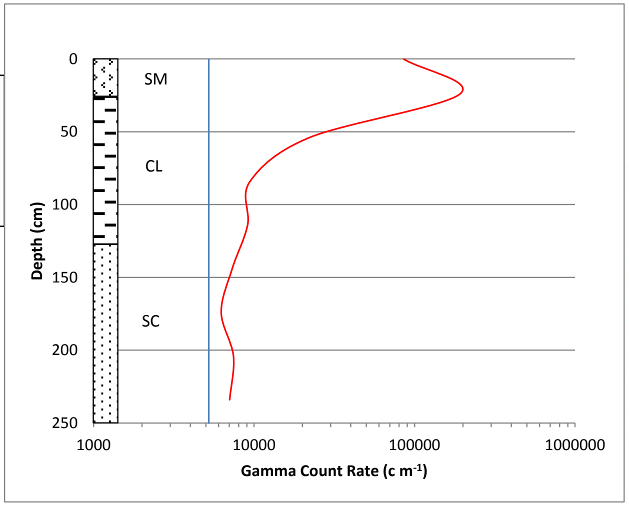
### Relevant Radionuclide Results in Soil Samples

| Sample ID | Depth (cm) | Radium-226 | | Thorium-230 | | Uranium |
|---|---|---|---|---|---|---|
| | | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ | TPU | pCi g$^{-1}$ |
| AA-12-SS-0015-101512 | 0-15 | 194 | 23 | 478 | 73 | 175 |
| AA-12-SS-15115-101512 | 15-115 | 79.6 | 9.3 | 198 | 31 | 64 |
| AA-12-SS-115245-101512 | 115-245 | 7.02 | 0.83 | 32.3 | 5 | 25 |

cm = centimeters
mg kg$^{-1}$ = milligrams per kilogram
pCi g$^{-1}$ = picocuries per gram
TPU = total propagated uncertainty

SC = clayey sand
SM = waste rock
CL = clay

Vertical line is cutoff value



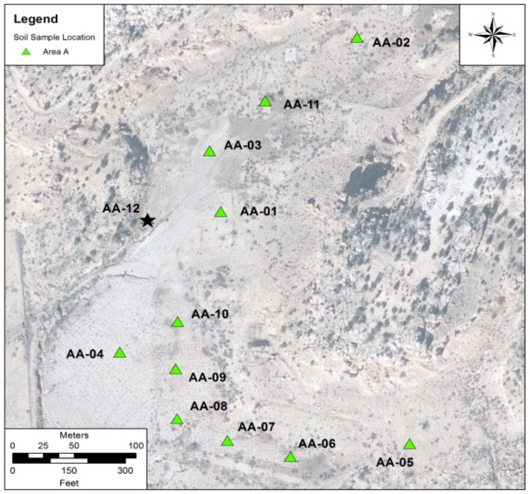




**Figure 4-30. Down-hole Logging and Soil Sample Results: Boring AA-12**

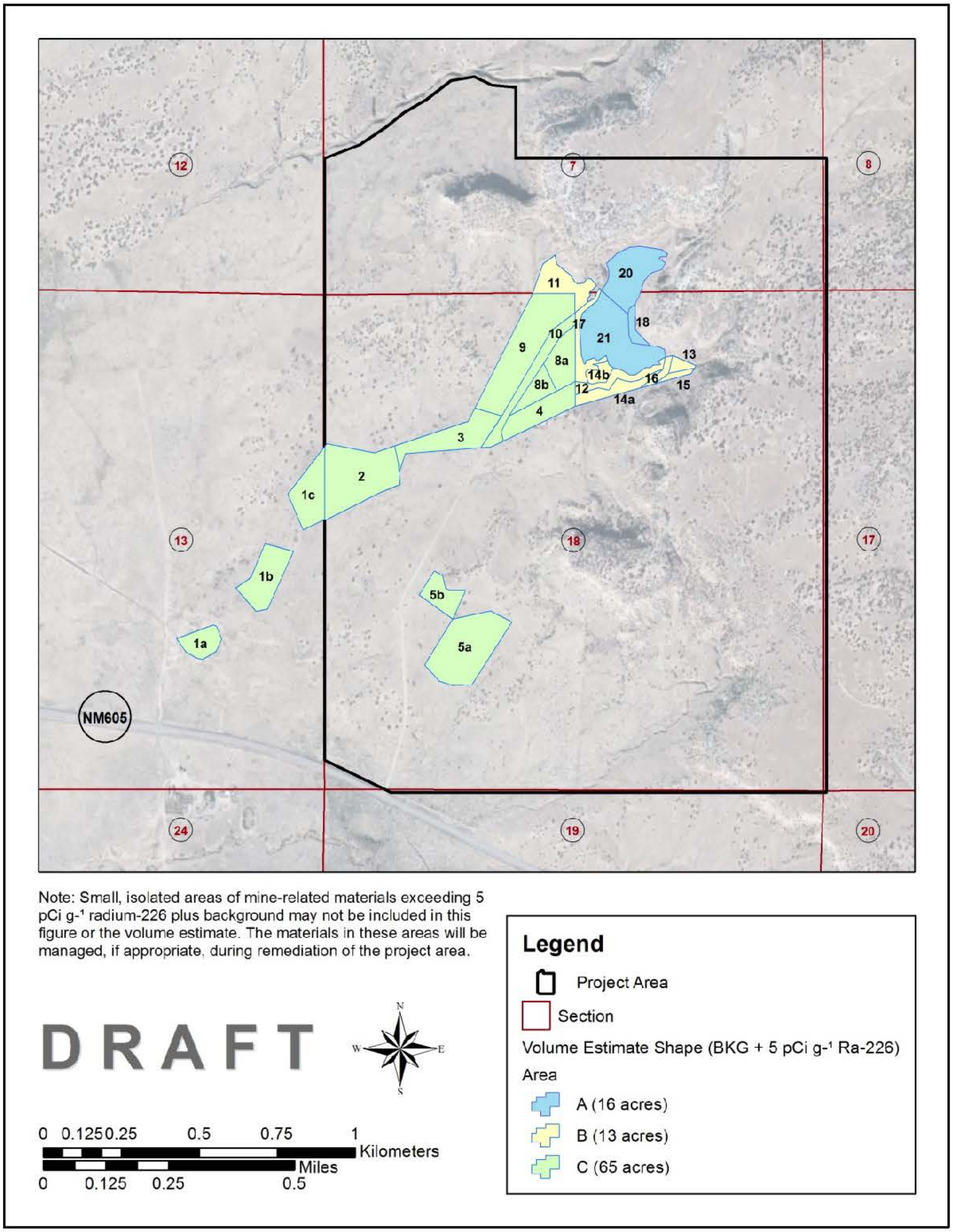



**Figure 4-31. Shapes used to Estimate Areas and Volumes for Delineation to Background Plus 5 pCi g$^{-1}$ Radium-226**

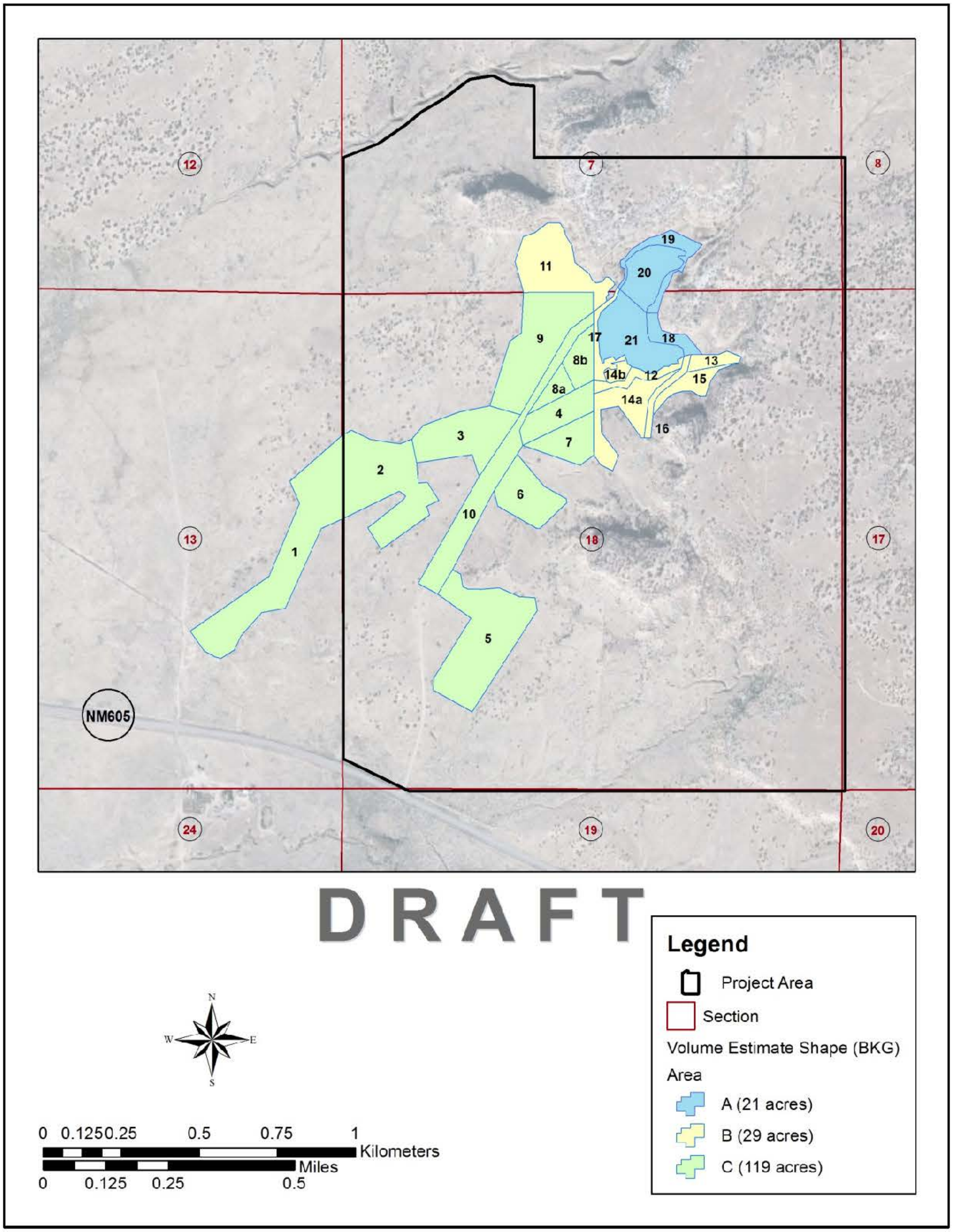



**Figure 4-32. Shapes used to Estimate Areas and Volumes for Delineation to Background Concentration of Radium-226**